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MILESTONE 6
FINAL REPORT

June 30 2003

HIGH-CAPACITY TRANSIT STUDY

Maricopa Association of Governments

Executive Summary

Introduction

The High Capacity Transit Study presents a network of new transit services designed to meet growing travel demand in the Maricopa Association of Governments' (MAG) region. This long-range study considers projected travel demand in the MAG region with a forecast horizon year of 2040 when the MAG region population is expected to reach over 7 million residents. The Draft 2 MAG Population and Employment forecasts were used as the base for estimating ridership and travel demand in the region. These forecasts incorporate updated general plan land use information from each city in the MAG region. The findings and recommendations contained in this report will be considered in the development of the Regional Transportation Plan (RTP), which will provide a policy framework to guide regional transportation investments over the next twenty years.

High capacity transit encompasses several different technologies, each designed with different operating characteristics and objectives for moving people. The focus of this study was to identify proven transit technologies that were capable of meeting the levels of travel demand projected in the MAG region while also serving several types of trips, both long-range and shorter distance. Therefore, the study focused on the three most prevalent existing and emerging forms of high capacity transit in North America: commuter rail, light rail transit, and bus rapid transit.

The overall objective of the Recommended High Capacity Transit Network is the creation of an integrated system of high capacity transit corridors providing efficient and convenient travel throughout the MAG region. An important part of these corridors fulfilling their objective is to ensure that there are connections between the corridors and that these connections facilitate the movement of riders between systems no matter which transit technology is being operated. The exhibit on the following page illustrates the Recommended High Capacity Transit Network. The likely connection points between each corridor and intersecting corridors are illustrated in this map.

RECOMMENDED HIGH CAPACITY TRANSIT NETWORK

E1.0 Study Process

The High Capacity Transit Study process was performed over the course of a 16 month timeframe. The Scope of Work for the project was divided into six milestones described below:

- Study Initiation - Scope of Work, public involvement plan, review of past studies, and comparison of high-capacity transit technologies.
- Needs and Opportunities - Identification of transit performance thresholds, development modeling methods, and inventory of rail infrastructure.
- Identification of Alternatives - Commuter rail feasibility, definition of a network of services, and identification alternative high-capacity concepts.
- Evaluation of Alternatives – Identification of costs, projections for ridership levels, and evaluation of a range of transit alternatives and potential corridors.
- Regional Commuter Rail/High-Capacity Transit Plan - Recommendation a transit network and preparation of an implementation plan.

The sixth and final project milestone is the release and adoption of the High Capacity Transit Study Final Report.

E1.1 Public and Agency Involvement Plan

The Public and Agency Involvement Plan (PIP) provided an overview of public involvement objectives for the MAG High Capacity Transit Study, as well as specific actions that will be carried out by the consulting team in association with MAG staff.

The High Capacity Transit Study PIP applied a three-tiered approach to optimize public participation in the planning process:

- **Listen to the community.** Gather useful information by talking with key players. The goal is to get all of the issues "on the table" early in the study process. This way, all concerns can be addressed at each stage of the High Capacity Transit Study. Stakeholder briefings were held with with nearly 30 stakeholders representing 16 organizations, agencies, and jurisdictions in Maricopa County. These meetings helped to set objectives for the study and focus areas for analysis.
- **Integrate information.** Work with local agencies to share recommendations as the study progresses. Provide interagency coordination to ensure consensus is maintained throughout the study process. The Agency Working group was formed as part of this effort to meet throughout the course of the study. The group of staff members

from several cities in the MAG region provided a substantial amount of input into the Milestone reports.

- **Share information.** Provide informative, comprehensive information to the public. Showcase the public involvement process within the region. Public open houses were conducted during the Fall and Winter of 2002 to present the study to the general public and receive feedback that could be incorporated into the study recommendations.

E1.2 Review of Current and Previous Transportation Studies

The High Capacity Transit Study was conducted concurrently with several other transportation studies and projects. Results from these other study efforts were reviewed during the development of this study to identify ways that the High Capacity Transit Study could be coordinated with the recommendations of the studies and proposed projects. Regular working group meetings were held with the representatives developing the other studies to share results and conclusions to ensure consistency in the recommendations of several studies that will be incorporated in the Regional Transportation Plan.

Selected current and recent regional transportation studies reviewed during the development of recommendations for this report included previous commuter rail demonstration studies, the Central Phoenix/East Valley MIS, the Scottsdale-Tempe North-South MIS, the Chandler Transit MIS, the three MAG Area Transportation Studies (Northwest, Southwest, Southeast), and the MAG Fixed Guideway Transit Study.

E2.0 High Capacity Transit Characteristics and Thresholds

Commuter Rail in Dallas, TX

Heavy Rail in Chicago, IL

Light Rail in San Diego, CA

Automated Guideway Transit in Miami, FL

Bus Rapid Transit in Las Vegas, NV

A comprehensive review of high capacity transit technologies was needed to identify technologies capable of meeting the projected travel patterns and demand present in the study area.

E2.1 General Characteristics of High Capacity Transit

Five proven transit technologies were evaluated for implementation in the transit corridors identified in the High Capacity Transit Study. In addition to these proven technologies, several other existing and new technologies were studied, including Diesel Multiple Unit (DMU) vehicles. The five primary transit technologies evaluated were commuter rail, heavy rail, light rail transit (LRT), automated guideway transit, and bus rapid transit (BRT).

E2.2 Peer Group Transit System Review

The three most common transit technologies were selected for inclusion in a peer-group review of transit systems. The three technologies were commuter rail, LRT, and BRT. These technologies were selected because of their prevalence in North America and their potential appropriateness for implementation in the MAG region.

Table 2-1 lists the six transit systems for each of the three technologies included in the peer group review. Operating data for the Year 2000 and socio-economic data for selected systems was collected from each agency and the United States Census.

Table 2-1 **General Peer Group Review Transit Systems**

Commuter Rail	Light Rail	Bus Rapid Transit
Los Angeles - Metrolink	Los Angeles - Green Line	Los Angeles - Metro Rapid
San Diego - Coaster	San Diego - Blue Line (Mission Valley)	Miami – South Miami-Dade Busway
San Jose - Altamont Commuter Express	Dallas - Red and Blue Lines	Pittsburgh – South, East, and West Busways
Dallas - Trinity Railway Express	Denver – Central and Southwest Lines	Vancouver – Richmond to Vancouver Rapid Bus
Toronto – Lakeshore East Line	San Jose – VTA Light Rail	Ottawa – Transitway
Chicago – South Shore Line	St. Louis – Metrolink	Washington DC – Dulles Corridor BRT

Analysis of Peer Group Data

The three peer group systems selected for inclusion in the detailed data review possess a wide variety of population and employment densities. Specific patterns emerging from the data include:

- Commuter rail is capable of maintaining successful operations with lower population and employment densities than LRT/BRT corridors.
- Each light rail or BRT system serves a minimum of one employment center (greater than 50 employees per acre) while two of the selected commuter rail systems serve corridors with more dispersed employment centers and no census tracts with greater than 50 employees per acre.
- All but one transit system operates within a metropolitan region with over 50 percent of the region's freeway lanes miles extremely or severely congested.
- Average trip lengths for commuter rail systems are a minimum of 25 miles. These averages are between four and nine times as long as the average trip lengths for light rail and BRT.

The peer group review also examined population densities for several representative corridors in the MAG region and compared them to the data collected on the peer review transit systems. The results from the MAG region were generally comparable with the existing transit systems throughout North America.

The photos above present three of the peer group transit systems reviewed in this study: Commuter Rail in Los Angeles, CA, Light Rail in San Jose, CA, and Bus Rapid Transit in Miami, FL.

E3.0 MAG High Capacity Transit Corridor Identification

During the development of the High Capacity Transit Study, 29 corridors were identified for possible inclusion in the Recommended Network. For the purposes of analysis, a single representative alignment was selected for each of these corridors. However, these specific alignments are designed to represent all parallel alignments in the corridor including streets, freeways, rail lines, and non-traditional corridors such as canals or power-line easements.

These corridors were developed from three sources:

1. Current and past major transportation studies in the MAG region.
2. Suggestions of agency representatives in the stakeholder interviews.
3. Existing and future demographics and travel patterns in the region.

Three major corridors in the MAG region are illustrated above: I-10 West (top), Union Pacific Southeast (center), and Camelback Road (bottom).

Two networks of proposed transit enhancements were developed using the corridors identified above. Each of these networks was developed using a set of base transit alternatives, which included both a radial and grid orientation to providing service. Potential commuter rail, LRT, and BRT services are included within each network, and are illustrated in Exhibits 4-1 and 4-2. These networks were used as the basis for evaluating the corridors and identifying locations where individual corridors could connect and create an integrated regional network. Summaries of the two transit networks are provided below:

Network 1 – This network is a combination of commuter rail, Express BRT and LRT/Dedicated BRT systems, serving both long and short distance trips with a series of radial alignments.

Network 2 – This network is designed to serve long and short distance trips with long distance radial corridors linked to the grid system of LRT and BRT service.

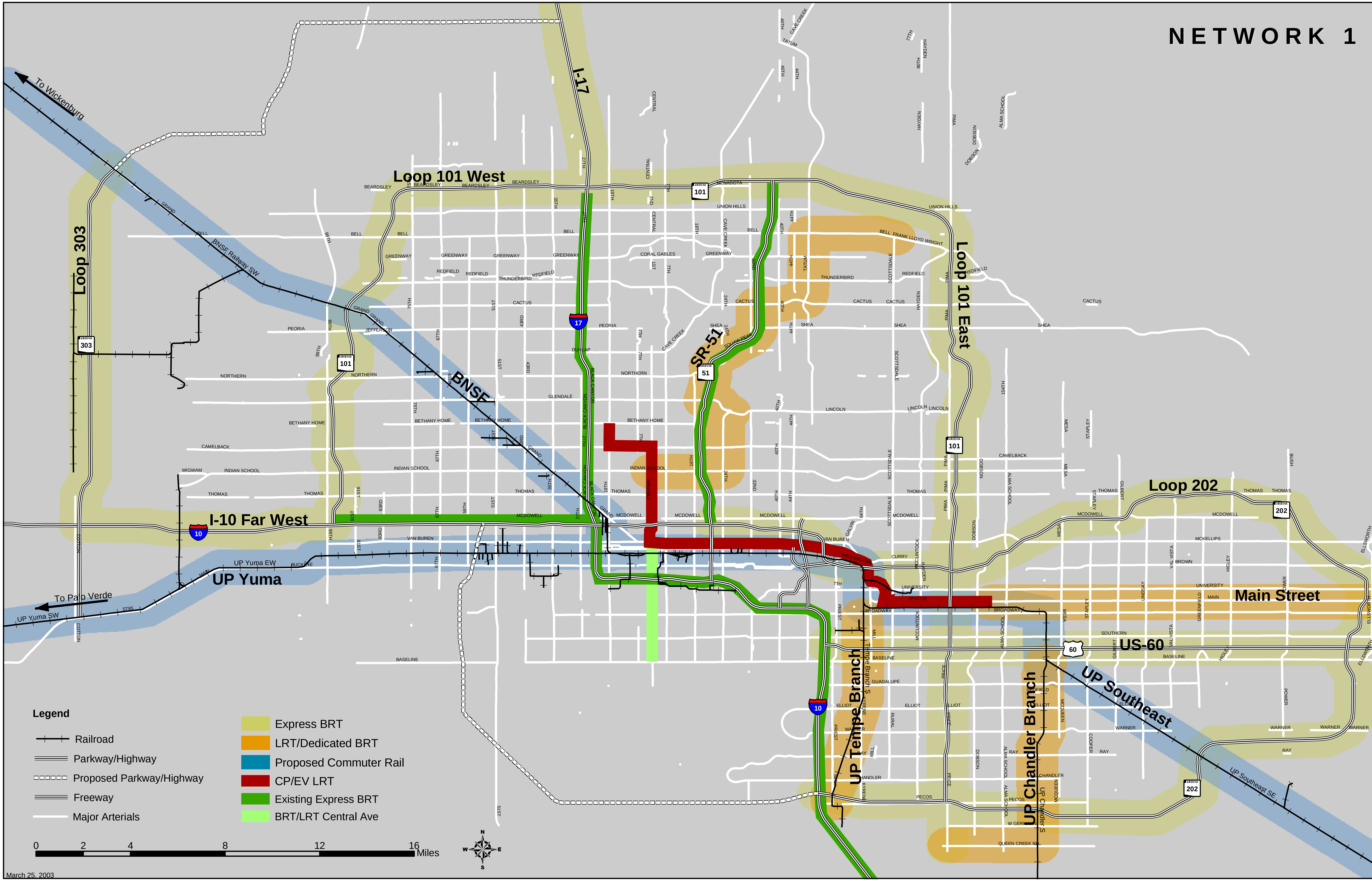
The corridors developed using these sources were numerous, and in many cases, the corridors overlapped or served the same markets. As a solution to this issue, multiple parallel corridors were combined or modified so that the various rail, arterial street, freeway or flood control channel rights of way could easily map to a specific major corridor. The results of these combinations are presented in the ridership and cost estimates in Section 4.

During the initial screening process, several corridors were eliminated from further consideration. In particular, all identified Express BRT corridors were not studied further. These corridors possess operating characteristics which are very different from those of commuter rail, LRT, or Dedicated BRT systems. The evaluation of the Express BRT corridors was shifted to the Valley Metro/RPTA Regional Transit System Study since it was determined that the Express BRT corridors “fit” better with the scope of this study.

E3.1 Commuter Rail Network and Operating Characteristics

Three levels of service for the operation of a commuter rail system were initially identified for the MAG region.

- Phase 1: Start-Up/Introductory Services: limited peak hour, peak direction service composed of three trains inbound in the a.m. peak and outbound in the p.m. peak on each of the corridors.
- Phase 2: Intermediate Services: Headways of 20 minutes peak hour will be examined together with limited counter-flow service. Midday service would consist of hourly trains in each direction.
- Phase 3: Full Commuter Train Operation: 15 minute headways during the peak hours and at 30 minute headways during the off-peak, with peak period 30 minute interval counter-flow services.


NETWORK 1
I-17
Loop 101 West
Loop 101 East
Loop 303
Loop 202
SR-51
I-10 Far West
UP Yuma
BNSF
BNSF Railway SW
UP Yuma EW
UP Yuma SW
To Wickenburg
To Palo Verde
Main Street
US-60
UP Southeast
UP Southeast SE
UP Tempe Branch
UP Chandler Branch
Legend
Railroad
Parkway/Highway
Proposed Parkway/Highway
Freeway
Major Arterials
Express BRT
LRT/Dedicated BRT
Proposed Commuter Rail
CP/EV LRT
Existing Express BRT
BRT/LRT Central Ave
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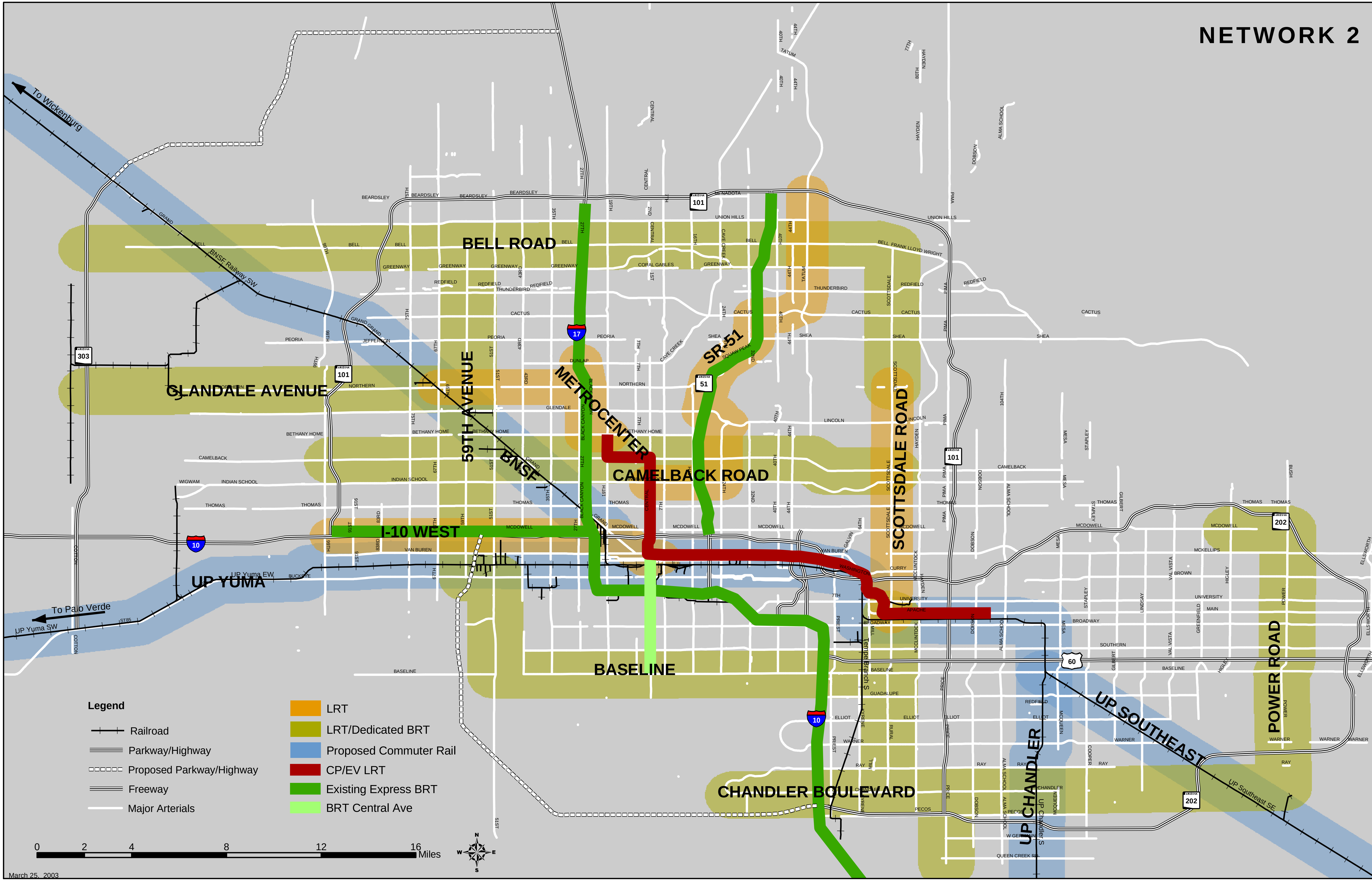
12
16
Miles
March 25, 2003


NETWORK 2
BELL ROAD
GLANDALE AVENUE
59TH AVENUE
METROCENTER
SR-51
CAMELBACK ROAD
SCOTTSDALE ROAD
I-10 WEST
UP YUMA
BNSF
BASELINE
CHANDLER BOULEVARD
UP CHANDLER
UP SOUTHEAST
POWER ROAD
To Wickenburg
To Palo Verde
BNSF Railway SW
UP Yuma SW
UP Southeast SE
Legend
Railroad
Parkway/Highway
Proposed Parkway/Highway
Freeway
Major Arterials
LRT
LRT/Dedicated BRT
Proposed Commuter Rail
CP/EV LRT
Existing Express BRT
BRT Central Ave
0 2 4 8 12 16 Miles
N
S
E
W
March 25, 2003

These three levels of service were used to develop the ridership and cost estimates in Section 4. Based upon the results of the capital cost estimates and discussions with representatives from BSNF and UP, it was determined that only the Phase 1 and Phase 3 levels of service would be carried forward for further evaluation. Phase 1 service represents the minimum amount of service that needs to be provided to operate a potentially viable commuter rail service, with three trains operating during the peak commute. Phase 3 service would be the ultimate operation of commuter rail service which would provide residents of the MAG region with a true "turn up and go" service providing frequent and reliable service throughout the day during both peak and off-peak commute times.

Infrastructure Requirements

Discussions were held with Burlington Northern Santa Fe (BNSF) and the Union Pacific (UP) Railroads to identify infrastructure enhancements required for implementing commuter rail service in freight rail corridors in the MAG region. In summary, assuming no changes to the operating practices of BNSF and UP, a second main track will be required on the BNSF line between downtown Phoenix and Surprise. The Union Pacific corridor will require a second main track between downtown Phoenix and the McQueen Junction in Gilbert, just south of US-60. Additional infrastructure improvements required in these corridors include stations, signals, and sidings to allow for trains to pass each other. A full discussion of the infrastructure requirements by segment is included in the Milestone 3 Report.

Common Issues in Commuter Rail Operations

Over the past two decades, there has been a wave of "start-up" commuter rail operations, particularly in the western United States. Based on that experience, the following are some typical issues likely to arise in ongoing discussions of commuter rail in the MAG region including potential resolution mechanisms and lessons learned from other systems.

- Ownership – The commuter rail agency can either purchase frieght right-of-way or lease access.
- Capacity Conflicts – Coordination between passenger rail and freight rail traffic is essential to ensure efficient operations for both.
- Grade Crossings – Street/rail crossings could cause impacts to automobile traffic in the corridor.
- Noise – Additional rail traffic can impact sensitive uses.
- Station Impacts – Additional automobile traffic is created near stations as commuters access park-and-ride facilities.

- Capital Needs – Rail infrastructure and vehicles must be purchased and maintained.
- Governance – How is the system administered when the corridor passes through several jurisdictions.

Conventional commuter rail locomotive technology is illustrated in the top photo. A new DMU vehicle from Colorado Rail Car is shown in the bottom photo.

Commuter Rail Equipment

All new start commuter rail systems in North America have been equipped with an almost uniform configuration of a diesel locomotive-hauled train of double deck cars. Commuter rail services in this configuration are operated in push-pull mode, with a locomotive at one end and a cab car at the other end; these trains can reverse without any changes to the train makeup. This study examined the operation of this technology in the MAG region along with a new technology in North America called diesel multiple unit (DMU) trains. A comparison of these technologies is included in Section 4.

E3.2 LRT/Dedicated BRT Network and Operating Characteristics

In addition to commuter rail services, other types of high capacity transit services are also being considered for implementation in the MAG region. These alternative high capacity transit services include LRT and BRT. Corridors that present possible alignments for LRT and BRT services include arterial streets, freeways, and non-traditional transportation corridors such as utility easements and flood control channels. Both technologies are capable of being implemented in either elevated or at-grade configurations. Additional options for minimizing traffic impacts and improving system operating speeds are also available in form of reserved rights-of-way or exclusive travel lanes.

The Green Line light rail in Los Angeles, CA operates in a freeway median.

Technology Comparison

An important determination made during the development of the BRT and LRT corridors is the identification of which technology is better suited for implementation in a particular corridor. Both LRT and BRT are extremely flexible transit services capable of operating in a variety of corridors and configurations. In terms of operational characteristics, BRT and LRT both have advantages and disadvantages that would need to be analyzed on a corridor-by-corridor basis in order to determine the right technology "fit" for new high capacity transit system. A detailed Major Investment Study (MIS) is required to fully and properly analyze each technology.

Bus Rapid Transit in Ottawa, Canada is operated in an exclusive transitway.

	Light Rail Transit	Bus Rapid Transit
Advantages	• Positive impact upon land use development within the corridor • Increased vehicle capacity	• Flexibility in operating and phasing • Ability to operate as short-term service
Disadvantages	• Limited ability for phased implementation • Higher capital investment cost than BRT	• Image of bus vehicles as slow • Reduced vehicle capacity

Each of these technologies is highly scalable and the implementation of one technology tends to encourage the continuation of that technology in future expansions and extensions of the initial corridor. However, selecting one technology over the other does not preclude the implementation of both LRT and BRT in the same metropolitan region. These two technologies coexist in many regions including Los Angeles, Pittsburgh, and Cleveland. In the end, technology selection is not only a local decision, it is a regional one that should include input from all stakeholders region-wide to order to bring the greatest benefit to the largest number of people.

E4.0 Ridership and Cost Estimates

Cost and ridership are provided in this section for the potential high capacity transit corridors in the MAG region. As noted previously, each alignment identified in the tables below represents a single centerline street or freeway selected for ridership, cost and socio-economic data estimates. The actual corridors are approximately five miles in width and a final alignment could include other streets parallel to the alignments identified. Ridership and cost estimates were developed using population projections, operating and implementation characteristics of peer systems, and input from the Agency Working Group, a committee of representatives from MAG, local cities, Valley Metro, and the Arizona Department of Transportation who convened throughout the study process to review and refine the inputs and results of this study. Exhibit 4-1 illustrates the high capacity transit network recommended for evaluation and the development of ridership and cost estimates.

E4.1 Commuter Rail Ridership

Commuter rail ridership was forecast using a direct demand model (DDM). The more traditional four stage modeling approach was considered less suitable at the initial stage due to the absence of commuter rail as a mode in the MAG model, and the much slower application of this model when compared to the quick sketch planning forecasts that the DDM can produce. Instead, the four-stage MAG model was used to evaluate the overall Recommended High Capacity Transit Network. The results of this model evaluation are presented later in this report.

The DDM estimates weekday boarding passengers per station based on the catchment population and level of service factors such as train frequency and journey time savings. Station catchment areas were developed for each proposed station to represent the major source of all trip origins within a ten mile radius, taking into account for land use development patterns present in the MAG region and likely travel distances for commuters based upon reviews of riders from other West Coast commuter rail services.

Table 4-1 displays the average weekday ridership forecast for the corridors.

Table 4-1 **Commuter Rail Total Ridership Forecasts**

Corridor	Total Boardings	
	Initial 2020 - (Phase 1)	Ultimate 2040 - (Phase 3)
BNSF	4,900	16,100
UP Mainline/Chandler	1,400	4,600
UP Southeast	2,000	6,500
UP Yuma	2,700	12,000

Note: These boarding figures have been obtained from a sketch planning model.

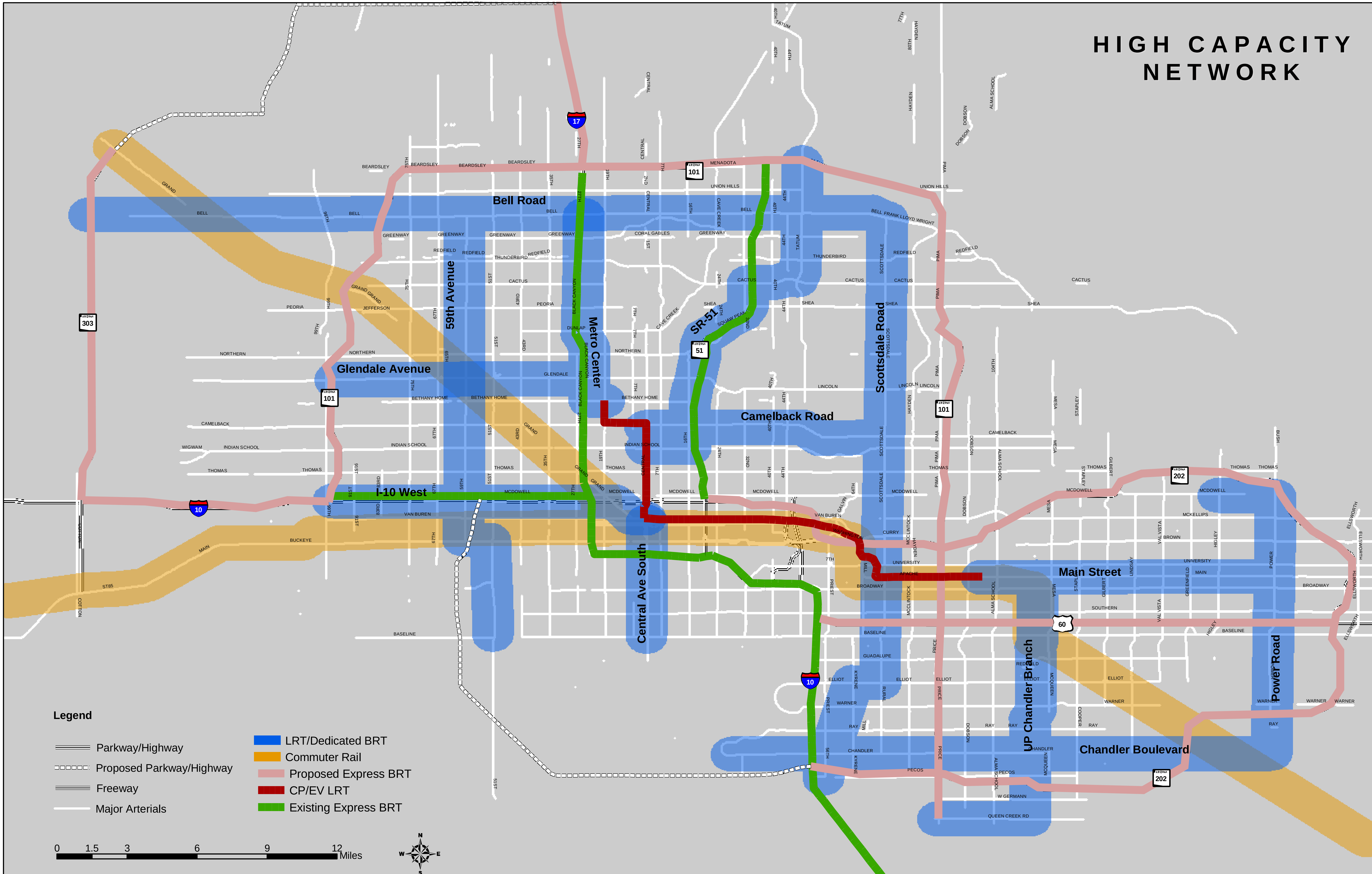
E4.2 Commuter Rail Capital and Operating Costs

Capital and operating costs have been developed for the four alternative commuter rail corridors consistent with the phased levels of service described above using conventional locomotive-hauled equipment. Capital costs were developed using standard unit cost rates obtained from several rail infrastructure cost estimates prepared for West Coast rail properties during the previous five years. Commuter rail operating costs have been estimated using the comparison of Year 2001 bus and commuter rail operating and maintenance costs from three commuter rail service providers, the Dallas Trinity Railway Express, San Diego Coaster, and San Jose Altamont Commuter Express. Table 4-2 summarizes the capital costs for each commuter rail corridor by phase.

Table 4-2 **Commuter Rail Capital & Operating Costs**

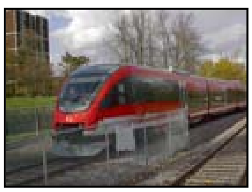
Commuter Rail Corridor	Capital Costs ($ millions)	Annual Operating Cost ($ millions)
BNSF Phase 1	$290	$5
BNSF Phase 3	$446	$22
BNSF Capital Cost Total	**$736**	n/a
UP Mainline/Chandler Phase 1	$270	$2
UP Mainline/Chandler Phase 3	$260	$14
UP Mainline/Chandler Capital Cost Total	**$530**	n/a
UP Southeast Phase 1	$270	$3
UP Southeast Phase 3	$297	$17
UP Southeast Capital Cost Total	**$567**	n/a
UP Yuma Phase 1	$143	$4
UP Yuma Phase 3	$309	$22
UP Yuma Capital Cost Total	**$452**	n/a

Note: All costs are in millions of dollars and Year 2001 dollars.


HIGH CAPACITY NETWORK
Bell Road
Glendale Avenue
59th Avenue
Metro Center
SR-51
Scottsdale Road
Camelback Road
I-10 West
Central Ave South
Main Street
UP Chandler Branch
Power Road
Chandler Boulevard
Legend
Parkway/Highway
Proposed Parkway/Highway
Freeway
Major Arterials
LRT/Dedicated BRT
Commuter Rail
Proposed Express BRT
CP/EV LRT
Existing Express BRT
0 1.5 3 6 9 12 Miles
N
W
E
S
Network Map - Wide Corridors

Alternative Commuter Rail Technologies

The Diesel Multiple Unit (DMU) rail vehicle has been successfully used in Europe for many years, but had not appeared in North America due to the inability of existing designs to meet Federal Railroad Administration (FRA) safety regulations. However, several manufacturers are developing FRA-compliant DMU vehicles. Given the long-term nature of this study, it is reasonable to explore a scenario where DMUs are fully certified by the FRA for use in mixed freight and passenger corridors.



The photos above illustrate the three commuter rail vehicles: conventional locomotive (top), Colorado Rail Car DMU (middle), and Bombardier Talent DMU (bottom).

DMUs possess several operational advantages over conventional locomotive trains. The DMU vehicles are usually less expensive than a comparable locomotive-hauled unit on a per passenger basis, are more fuel-efficient, and are capable of quicker acceleration and deceleration rates thanks to lower overall weight. Disadvantages include the need for additional vehicles if single-level vehicles are selected, possible increases in maintenance costs due to the relative uniqueness of the technology in North America, and possible limited life cycle.

Capital and operating costs have been developed for the implementation of commuter rail service using DMU trains and are presented in the Milestone 5 Report. The cost effectives of operating commuter rail service in the MAG region with the three types of rail vehicles is presented in Table 5-1 below. A full discussion of the calculation of cost-effectiveness in this report is presented in Section 5.

Table 4-4 **DMU Cost Effectiveness Comparison**

Corridor	Colorado Rail Car DMU Cost Effectiveness	Bombardier Talent DMU Cost Effectiveness	Conventional Locomotive Cost Effectiveness
BNSF Phase 3	$16.40	$16.31	$16.84
UP Mainline/Chandler Phase 3	$37.48	$32.82	$41.41
UP Southeast Phase 3	$30.07	$29.87	$33.83
UP Yuma Phase 3	$15.32	$15.43	$16.22

Note: All costs are in Year 2001 dollars.

As shown in the two tables above, DMU technology does offer a potentially cost-effective alternative to conventional locomotive-hauled commuter trains. The relative uniqueness of the DMU technology in North America may create some procurement and maintenance issues. However, as the technology becomes more prevalent, these additional risks and costs will be minimized. Given the long-term horizon of this study it remains prudent to retain DMU technology as a possible option for providing commuter rail service in the MAG region. The selection of a specific technology for commuter rail in a selected freight corridor in the MAG region would require a detailed Major Investment Study (MIS).

E4.3 Light Rail/Bus Rapid Transit Ridership

Similarly to the commuter rail forecasts, a direct demand modeling approach was used, in this case the MAG Sketch Plan Model, which is particularly suited to the level of detail required at this stage and was selected as a tool for the rapid development of corridor forecasts. Forecasts shown in Table 4-5 are for average daily ridership.

Table 4-5 **LRT/Dedicated BRT Ridership Projections**

Corridor	Average Daily Boardings
59th Avenue	12,800
Bell Road	19,800
Camelback	8,100
Central Avenue South	5,700
Chandler Boulevard	12,200
Glendale Avenue	7,200
I-10 West	13,800
Main Street	9,700
Metrocenter/I-17	8,900
Power Road	8,600
Scottsdale Road/Tempe Branch	20,700
SR-51	12,300
UP Chandler Branch	12,500

Notes: The boarding figures contained within this table have been obtained from a sketch planning model

Many of the corridors perform well in comparison with existing LRT systems in San Diego, Portland and Sacramento, including parts of the Scottsdale Road and Glendale Avenue corridors, Main Street, and the Metrocenter/I-17 corridor.

E4.4 Light Rail/Bus Rapid Transit Capital and Operating Costs

The LRT capital costs assume an at-grade alignment except when crossing rivers, flood control channels and freeways. In these locations, the alignment is elevated in order to minimize impacts to existing arterial streets and bridge facilities. These cost estimates are planning level estimates that have been produced without the benefit of detailed plans. More precise costs would be produced in the latter stages of project design and development.

Four corridors noted below do not have Dedicated BRT costs. Central Avenue South, Metrocenter/I-17, Glendale Avenue, and I-10 West were analyzed solely as LRT corridors, and as is the case with the other corridors, these alignments were selected to represent corridors approximately two to five miles in width. LRT has been identified as the preferred technology on Main Street in Mesa between the terminus of the CP/EV LRT and downtown Mesa. The preferred technology beyond this point has not been determined. As such, two costs estimates have been prepared for this corridor.

Light rail operating costs have estimated using a parametric model developed for the Tri-Met LRT system in Portland, Oregon. Model inputs have been adjusted by comparing bus operating costs for Valley Metro/RPTA with Tri-Met bus service. The use of these model inputs eliminates the need for comparisons between multiple light rail systems as was the case in developing commuter rail operating costs. Instead, the parametric model is designed to produce consistent results even when applied to different light rail systems in different metropolitan areas because the model is based upon the bus service costs within the metropolitan region. Operating costs for the Valley Metro/RPTA bus service in 2001 were used as a base for estimating the operating cost of Dedicated BRT service.

Table 4-6 presents the capital and operating costs for both the LRT and Dedicated BRT corridors.

Table 4-6 **LRT/Dedicated BRT Estimated Capital and Operating Costs**

LRT Corridor	LRT Capital Costs ($ millions)	LRT Annual O&M Cost ($ millions)	BRT Capital Costs ($ millions)	BRT Annual O&M Cost ($ millions)
59th Avenue	$730	$11	$360	$10
Bell Road	$1,100	$23	$540	$16
Camelback Road	$350	$8	$170	$5
Central Avenue South	$230	$5	n/a	n/a
Chandler Boulevard	$680	$10	$300	$7
Glendale Avenue	$430	$9	n/a	n/a
I-10 West	$400	$10	n/a	n/a
Main Street	$370	$9	$185	$5
Metrocenter/I-17	$340	$8	n/a	n/a
Power Road	$460	$8	$237	$4
Scottsdale Road	$1,010	$21	$466	$14
SR-51	$820	$14	$250	$9
Union Pacific Chandler Branch	$460	$10	$230	$7

Note: All costs are in Year 2001 dollars.

E5.0 Evaluation of Alternatives

The High Capacity Transit corridors identified in this study were evaluated using a measure of project cost effectiveness developed specifically for this study. Table 5-1 summarizes the results of the ridership and cost estimates presented in Section 4 above. Included in the final column of Table 5-1 is the cost effectiveness category. Cost effectiveness is a measure used by the Federal Transit Administration (FTA) as part of the Section 5309 "New Starts" program, which allocates federal capital funding for major transit investment projects. For this program the cost effectiveness of the project is measured using the following calculation:

(Project annualized capital cost + Project annual operating cost) – (Baseline annualized capital cost + Baseline annual operating cost) / (Total Project Annual Riders – Total Baseline Annual Riders) = Cost Effectiveness

This calculation relies upon a baseline of future transit assumptions and difference between the proposed project and this baseline set of improvements. The corridors and high capacity transit systems here have not been matched to a specific baseline level of transit investment, making it impossible to exactly match the calculation above. Instead, a modified calculation of cost effectiveness has been selected for this portion of the evaluation. This calculation is illustrated below:

(Project Annualized Capital Cost + Project Annual Operating Cost) / Project Annual Boardings = Cost Effectiveness

The cost effectiveness figures presented in this report are designed as a tool to compare the corridors under consideration in the High Capacity Transit Plan. It would not be appropriate or accurate to compare these figures to other projects such as the CP/EV LRT or other transit projects that have received a certain cost effectiveness rating from the Federal Transit Administration (FTA). This measure differs significantly from the measure used in this study. This cost effectiveness rating in this report should be used only to evaluate the corridors in this report against each other.

Benefit Cost

The Benefit Cost analysis, like the cost effectiveness calculation, reflects the relationship between ridership and costs. However, the results of the Benefit Cost are in inverse relation to those of the cost effectiveness calculation. It is important to recognize that the key additional factor at work in the Benefit Cost analysis is the level of roadway congestion forecast for the competing arterial or freeway segment. The Benefit Cost figures identified in this report are designed to act as a check against the cost effectiveness ratings received by each of the corridors, and to assist in recommendations for phasing and prioritization. A full discussion of the Benefit Cost results and methodology is provided in Milestone 5.

Table 5-1 **Cost Effectiveness**

Corridor	Length (miles)	Annual Boardings	Annual Capital Cost ($ millions)	Annual Operating Cost ($ millions)	Cost Effectiveness	Benefit Cost
I-10 West	11	5,024,000	$32	$10	$8.41	2.64
Union Pacific Chandler Branch	13	4,575,000	$37	$10	$10.34	0.96
Metrocenter/I-17	9	3,230,000	$27	$8	$10.72	1.87
Main	10	3,540,000	$30	$9	$10.98	1.11
Central Avenue South	5	2,099,000	$18	$5	$11.00	0.50
Camelback	9	2,966,000	$28	$8	$12.00	1.31
Scottsdale Rd/Tempe Branch	26	7,545,000	$81	$21	$13.49	1.61
Power	13	3,158,000	$37	$8	$14.40	0.72
Chandler Blvd.	17	4,462,000	$55	$10	$14.44	0.97
59th Ave	19	4,683,000	$58	$11	$14.85	2.04
Bell	29	7,209,000	$88	$23	$15.36	1.75
UP Yuma	31	3,610,000	$36	$22	$16.22	4.19
Glendale Avenue	10	2,637,000	$34	$9	$16.42	1.05
BNSF	26	4,844,000	$59	$22	$16.84	1.69
SR-51	17	4,502,000	$66	$14	$17.82	2.28
UP Southeast	36	1,859,000	$45	$17	$33.83	1.30
UP Mainline/Chandler	28	1,368,000	$42	$14	$41.41	n/a

Notes: All ridership figures have been obtained from a sketch planning model. All costs are in Year 2001 dollars. In the case of cost effectiveness the lowest figures represent the best performance, while in Benefit Cost the higher figures are the top performers.

E5.1 Analysis of Corridor Evaluation

The evaluation results make commuter rail service in the BNSF and UP Yuma corridors viable when compared to the LRT/Dedicated BRT corridors. The UP Southeast and UP Mainline/Chandler corridors still face challenges given the anticipated cost of implementing service. In light of these challenges, a recommendation has been made to eliminate the UP Mainline/Chandler corridor from consideration for commuter rail service. Nevertheless, it is recognized that this corridor on the UP Chandler Industrial Branch portion between Chandler and Mesa has a large level of travel demand. Given the results of the cost-effectiveness evaluation performed, it is apparent that this demand would be best served by an LRT/Dedicated BRT corridor paralleling the UP Chandler Branch. Commuter rail demand in the corridor between Mesa and downtown

Phoenix would still be served by the UP Southeast corridor. The UP Chandler Branch corridor was specifically reviewed in this analysis and received an excellent cost effectiveness rating (2nd overall). Given this performance by the LRT/Dedicated BRT technology, it is recommended that commuter rail no longer be studied for this corridor.

UP Southeast corridor remains in consideration for high capacity transit service because of the regional travel demand in the East Valley and the probable need for fast, long-distance transit service in this portion of the MAG region. Commuter rail is better suited to meeting this demand than are LRT and Dedicated BRT. The UP Southeast corridor faces several cost-related challenges. However, there are alternative operating strategies and technologies that could be implemented to reduce the overall cost of building and operating commuter rail service.

Additionally, the mobility characteristics and transit demand in the Baseline corridor suggest that an east-west corridor in the southern portion of the MAG region would merit inclusion in a further analysis to assess the suitability of high capacity transit service. Such analysis should extend at a minimum to the Broadway, Southern and Baseline arterials.

At this point in time, this study has a limited ability to produce direct comparisons between LRT and BRT in cost-effectiveness. The sketch planning model is not capable of distinguishing between technologies, preventing estimates of the differences in ridership between corridors. However, using the single estimated ridership figures, it is possible to identify specific corridors that would likely perform well with BRT service. In analyzing the ridership results from this study, it is likely that a number of corridors contained in the Recommended High Capacity Transit Network would operate effectively with the implementation of BRT service rather than LRT, given this technology's capability to provide a comparable level of service at a much lower cost. Table 5-2 summarizes the cost effectiveness of both transit technologies in the MAG region and illustrates that BRT would prove to be a cost-effective alternative in many corridors.

Table 5-2 **LRT-BRT Cost Effectiveness Comparison**

Corridor	LRT Annualized Cost ($ millions)	BRT Annualized Cost ($ millions)	LRT Cost Effectiveness	BRT Cost Effectiveness
59th Avenue	$69.51	$40.02	$14.85	$8.55
Bell Road	$110.73	$65.68	$15.36	$9.11
Camelback Road	$35.58	$20.88	$12.00	$7.04
Chandler Boulevard	$64.44	$34.22	$14.44	$7.67
Main Street	$38.85	$28.51	$10.98	$6.23
Power Road	$45.47	$38.85	$14.40	$10.98
Scottsdale Road	$101.82	$27.21	$13.49	$8.61
SR-51	$80.20	$58.23	$17.82	$7.72
Union Pacific Chandler Branch	$47.31	$34.71	$10.34	$7.71

MAG Modeling Results

To assist in the evaluation of the Recommended High Capacity Transit Network the MAG four-step transportation model was used to forecast ridership and system utilization for all the corridors contained in the network. Previously, all corridor ridership projections were the result of sketch planning forecasts, which forecasted ridership in each corridor independently. This limitation of the sketch planning model prevented analysis of the entire recommended network operating as a cohesive unit. Overall, the MAG model forecasts around a third more riders than the sketch planning methodology. However, two corridors - Bell Road and the BNSF commuter rail line - can explain over 80 percent of this discrepancy. There are technical reasons for the high MAG model ridership along these corridors, particularly the large forecast growth in the northwest valley. These reasons are fully discussed in an addendum to the Milestone 5 Report. If these two corridors are removed, overall ridership is only 7 percent above the sketch planning results. Table 5-3 compares the sketch planning and four-stage modeling results for subareas in the MAG region.

Table 5-3 **Comparison of Modeling Results by Corridor Group**

Corridor Group	MAG Model Forecast	Sketch Plan Forecast	Difference
BNSF/Bell Road	85,907	27,823	209%
Central Network	137,185	107,063	28%
UP Yuma/I-10 West	21,034	19,783	6%
East Valley[1]	110,555	109,004	1%
Other	29,634	30,912	-4%
TOTAL (Adjusted)[2]	**210,798**	**195,722**	**8%**

This grouping shows that while comparisons on a line-by line basis may suggest large differences between the modelling approaches, overall differences are much smaller. The largest impact outside of the congestion and population influences of the northwest appears to be the network effects of connectivity, slightly increasing overall ridership.

E5.2 Recommended High Capacity Transit Network

The overall objective of the Recommended High Capacity Transit Network is the creation of an integrated system of high capacity transit corridors providing efficient and convenient travel throughout the MAG region. An important part of these corridors fulfilling their objective is to ensure that there are connections between the corridors and that these connections facilitate the movement of riders between systems no matter which transit technology is being operated. Exhibit 5-1 illustrates the Recommended High Capacity Transit Network.

[1]Corridors: MetroCenter/I-17, Main Street and CP/EV as one, as well as Power, Chandler, UPSE, UP Chandler Branch
[2]Does not include BNSF or Bell Road. Forecasts do not add up to total as Metro Center-CP/EV-Main Street corridor is included in both "East Valley" and "Central Network" categories

RECOMMENDED HIGH CAPACITY TRANSIT NETWORK

E6.0 Implementation Plan

The levels of service described for each of the commuter rail, LRT, and Dedicated BRT corridors in this report represent the *ultimate level of service* that each transit technology must provide to accommodate the ultimate estimated ridership demand in the various corridors. An important component in developing a recommended high capacity transit network is determining when and how the corridors should be implemented. Proper phasing of projects is essential to ensure that growing ridership demands are met and that improvements are scaled to funding levels available. Several criteria are involved in determining the phasing-in of new high capacity transit service. These criteria are essentially similar from technology to technology; however, there are distinctive differences.

Commuter Rail

The Altamont Commuter Express is a recent start-up commuter rail service with 3 daily trains.

This study has explored three major phasing steps for implementing commuter rail service. Each phase represents a dramatic improvement in service above the previous level of service. There are several ways of transitioning between levels of service, including incrementally with as little as a single roundtrip train added each year, or improvements can be implemented through a larger jump from one phase to the next.

Light Rail

Light rail in Denver started as a short 5 mile system. Recent expansions have created a 2-line, 27-mile system.

Light rail is a very different technology from commuter rail in terms of its operating characteristics. LRT systems are designed to provide frequent, all-day service from the first day of implementation, unlike commuter rail which can be a viable service with only two to three trains operating each day. A primary reason for this initial implementation of frequent service is the large amount of capital investment required to implement LRT. Phasing in of LRT service would primarily consist of gradual shortening of headways and increased spans of service.

Bus Rapid Transit

The Los Angeles Metro Rapid is a limited-stop bus with signal priority. Future phases will include exclusive bus lanes.

BRT technology is similar to commuter rail in that the phasing of service is very flexible, and can be implemented of a series of small stages over time to allow for funding availability and ridership growth. The lower infrastructure requirements for BRT allow for minimal levels of investment to begin a basic service and the flexibility of BRT vehicles allows for a staged implementation over many years. Initial operation could consist of "rapid" buses operating with signal priority, progressing up to bus lanes and finally to exclusive corridors paralleling a street, freeway, or rail right-of-way.

E6.1 Phasing and Prioritization

Overall phasing of service may result in the total long-term capital cost of implementing transit service to be higher than if the service was implemented at full capacity immediately. However, the latter approach is not usually realistic given the cost investment required to implement a full service transit system. Similar to the development of a freeway network when a six-lane freeway is widened to eight lanes to meet growing demand, improvements are done to transit systems in phases to match growing ridership demand. This spreads the cost burden over several years or decades allowing for benefits to be provided at an earlier stage than if construction was delayed until the full system could be implemented.

The High Capacity Transit Study is designed to be the first step in developing and prioritizing the recommended network of high capacity transit services. This prioritization will continue at a more detailed level during the development of the Regional Transportation Plan (RTP). One of the main objectives of the RTP will be to set out a specific prioritization of the transit corridors identified in the recommended network using additional analysis of population and employment projections, estimation of funding availability, and extensive public consultation.

The 16 corridors contained in the Recommended High Capacity Transit Network have been categorized into three groups for the purposes of prioritization. The key considerations in setting forth the prioritization recommendations for the High Capacity Transit network are both quantitative and qualitative. They include:

- Analysis of population growth and anticipated timing of future growth.
- Estimated ridership.
- Linkages to the committed network of high capacity transit.
- The cohesiveness of the overall network, ensuring that future corridors link to previously implemented corridors.

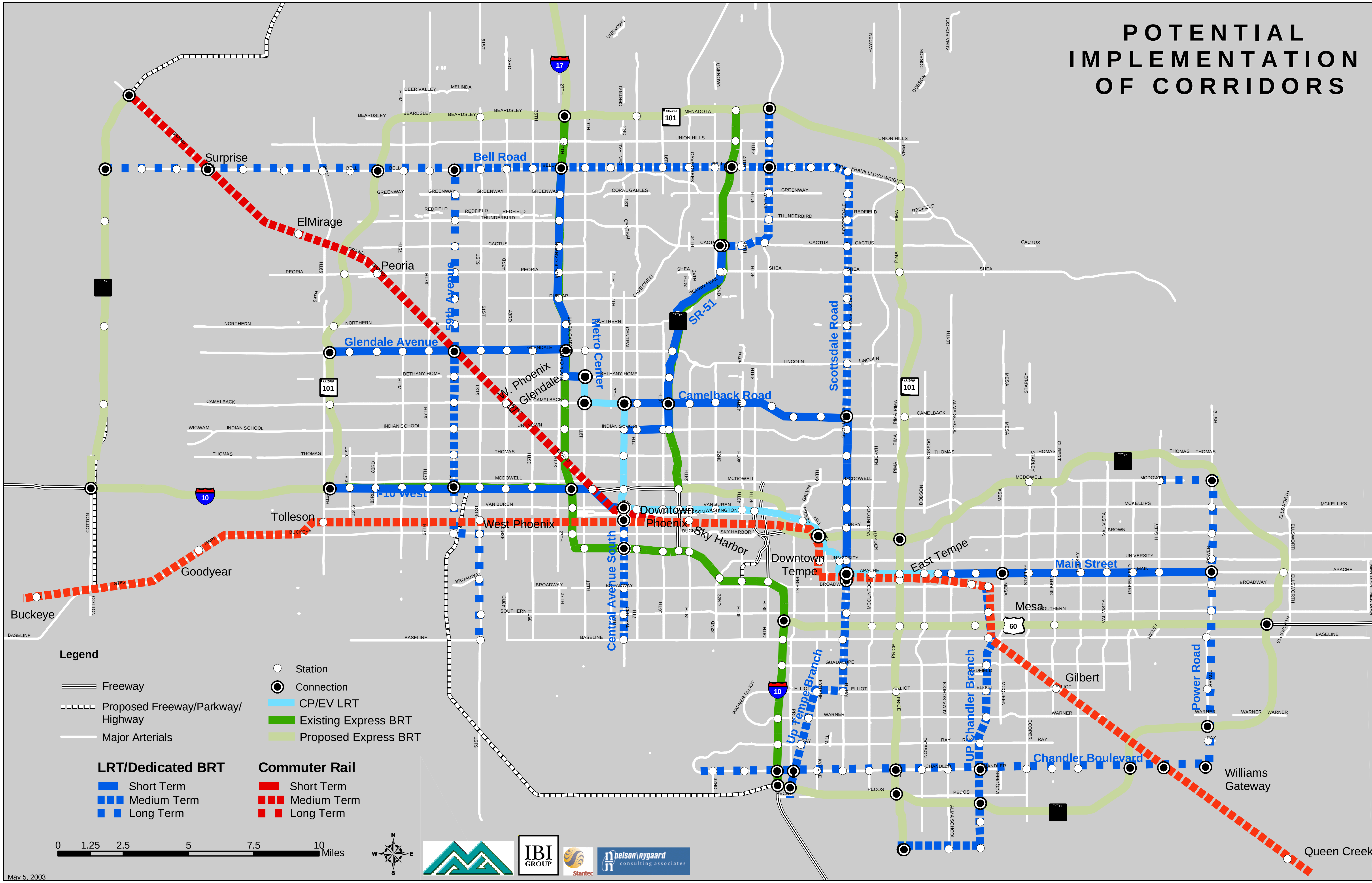
The three groups of corridors identified here have been classified as the Short-Term, Medium-Term, and Long-Term Implementation corridors. Assuming a 40-year horizon for the population and employment projections used in this report, the Short-Term corridors would likely be recommended for implementation during the next 15 years, while the Medium-Term corridors would be implemented within a 15-30 year time frame. The Long-Term corridors would complete the high capacity transit network during the final ten years of the study period. It is essential to note that these classifications are not permanent. They are designed as a guide for future refinement as part of the RTP process. Changes in population growth levels, timing, and the location of future growth would result in changes to the corridors contained in each level. The corridors recommended in each implementation level are identified in Table 6-1.

Table 6-1 **Recommended High Capacity Transit Corridor Phasing**

Short-Term Corridors	Medium-Term Corridors	Long-Term Corridors
Bell Road (59th Avenue to Scottsdale Road)	59th Avenue (Glendale Avenue to I-10 West)	59th Avenue (Bell Road to Glendale Avenue and I-10 West to Baseline Road)
BNSF (negotiations and MIS work)	BNSF (Start-up to Loop 303)	Bell Road (59th Avenue to Loop 303)
Glendale Avenue	Camelback Road	BNSF (Ultimate to Loop 303)
I-10 West	Central Avenue South	Chandler Boulevard
Main Street	Scottsdale Road/UP Tempe Branch (North of Downtown Scottsdale and South of CP/EV LRT)	Power Road
Metrocenter/I-17	SR-51 (Cactus Avenue to Loop 101)	UP Southeast (Ultimate)
Scottsdale Road/UP Tempe Branch (Downtown Scottsdale to CP/EV LRT)	UP Chandler Branch	UP Yuma (Ultimate)
SR-51 (Central Avenue to Cactus Avenue)	UP Southeast (Start-up with reverse commute to Williams Gateway)	
UP Southeast (negotiations and MIS work)	UP Yuma (Start-up)	
UP Yuma (negotiations and MIS work)		

There are recommendations for phased implementation of several of the corridors listed above to match forecasted population and employment growth within each corridor. While the implementation of commuter rail service has been identified for the medium term (15-30 years) period, it is recommended that work proceed in the short-term to advance the definition commuter rail service would be provided to the MAG region. Negotiations with freight rail operators and the development of a regional commuter rail governing organization is a time-consuming process that could take several years. Major investment studies (MIS) should also be prepared in corridors during the next 15 years to identify demand for service and service operating characteristics. The implementation of commuter rail is highly dependent upon population growth in the region. Early completion of MIS work will allow for flexible implementation of commuter rail service either prior to the medium term time frame should growth outpace projections or later in the 15-30 time period if growth does not occur as forecast in a specific corridor.

Exhibit 6-1 illustrates these corridors together as the Recommended High Capacity Transit Network.


POTENTIAL IMPLEMENTATION OF CORRIDORS
Bell Road
Glendale Avenue
59th Avenue
Metro Center
SR-51
Camelback Road
Scottsdale Road
W. Phoenix Glendale
I-10 West
Central Avenue South
Main Street
Up Tempe Branch
UP Chandler Branch
Chandler Boulevard
Power Road
Surprise
ElMirage
Peoria
Tolleson
West Phoenix
Downtown Phoenix
Sky Harbor
Downtown Tempe
East Tempe
Mesa
Gilbert
Goodyear
Buckeye
Williams Gateway
Queen Creek
Legend
Freeway
Proposed Freeway/Parkway/Highway
Major Arterials
Station
Connection
CP/EV LRT
Existing Express BRT
Proposed Express BRT
LRT/Dedicated BRT
Short Term
Medium Term
Long Term
Commuter Rail
Short Term
Medium Term
Long Term
0 1.25 2.5 5 7.5 10 Miles
IBI GROUP
Stantec
nelson\nygaard consulting associates
May 5, 2003

E6.2 Action Plan

The Recommended High Capacity Transit Network represents the culmination of a process that identified 29 potential high capacity transit corridors throughout the MAG region, refined these corridors, and evaluated them against each other to determine which corridors were best suited to serve growing demand for transportation capacity in the MAG region.

The next step in implementing the recommended network is the inclusion of these corridors in the development of the RTP. This study was the first step in the process of implementation. The next step is the RTP process which will involve a second review of the network corridors, a review of expect funding availability for transit improvements, and consultations with local agencies and the general public to further refine the number an coverage of the recommended corridors.

There are several specific next steps that need to be taken by MAG or local agencies in the MAG region either individually or in concert to ensure that proper preparations are made for providing future high capacity transit service in several of the corridors identified in the Recommended High Capacity Transit Network. Ideally these actions would begin immediately; however, given the need for approval of the RTP and its funding plan, some components may need to wait until the RTP is finalized. The tasks below are designed to be realistic objectives capable of being accomplished during the next three to five years. If these tasks are not completed in this timeframe, delays may be caused to later implementation steps and could delay components of the recommended network. The immediate actions are:

Refined Prioritization of Corridors in the RTP – The RTP process may introduce changes to the prioritization categories presented above. These changes must be determined early on so that local agencies understand the timing for funding availability and future implementation.

Relocation of the BNSF Freight Facilities – BNSF has been considering the relocation and consolidation of several freight rail facilities in downtown Phoenix to sites north of the BNSF mainline north of the existing intermodal facility in El Mirage. The relocation of the BNSF facility is not a simple process and will require extensive consultations between BNSF, local cities in the corridor, MAG, the Federal Railroad Administration (FRA), and the general public. This will likely be a long process for gaining approval of all parties involved and the identification of funding. This time frame makes it imperative that discussions begin soon to determine the feasibility of this strategy.

Begin Negotiations with Union Pacific – Negotiating access rights to freight railroad corridors can be a long drawn-out process that lasts for as many as five to 10 years depending upon the railroad, the local agency, and the operating characteristics of the corridor. It will be important to have a full understanding of what types of access rights UP will allow in both the UP Yuma and UP Southeast corridors in order to determine what capital costs will be involved in possible track upgrades and additions.

Develop a Specific Commuter Rail Network Plan – Previous studies have already considered commuter rail, largely on a corridor basis, but not in the context of the High Capacity Transit network. The analysis of Commuter Rail suggests very attractive ridership performance for the Startup Phase of commuter rail. However, a separate action-oriented plan is needed to assess the full viability of the startup service, take forward the initial discussions with UP and BNSF during the course of the High Capacity Transit Study, and run the network assumptions through an analysis based on the FTA New Starts criteria.

Perform Detailed Major Investment Studies on Early Implementation Corridors – Each corridor contained within the Recommended High Capacity Transit Network will require some form of Major Investment Study (MIS) to determine precise alignments, operating characteristics, preferred technology, and the overall design of the system. An MIS report includes a detailed refinement of costs, headways, and alignments, while including opportunities for community and policy input into the development of transit service. The outcome of an MIS is usually a more defined picture of what the high capacity transit service will look like in appear and operation. Several of these MIS efforts are underway or in early planning stages and include the Scottsdale-Tempe North-South Transit MIS and the City of Chandler Transit MIS. This recommendation is not intended to be duplicative of these efforts.

It is recommended that the Baseline corridor be included in a future Major Investment Study (MIS) to assess the suitability of high capacity transit options, which, as part of its alternatives analysis, also includes the parallel Broadway and Southern arterial streets. It also should be noted that the Central Phoenix/East Valley MIS studied high capacity transit in the City of Mesa east of the current terminus of the Central Phoenix/East Valley LRT. This MIS recommended the implementation of light rail, and as such, the recommendations of this report would not supersede this document. The work being done in these studies was incorporated into the development of corridors for evaluation in this report.

Future MIS reports will build upon the corridors identified in the Recommended High Capacity Transit Network. One of the first steps in this process will occur in the BNSF/Grand Avenue corridor where a recently announced MIS will evaluate both commuter rail and bus rapid transit alternatives.

1.0 Introduction and Project Management

The High Capacity Transit Study presents a network of new transit services designed to meeting growing travel demand in the Maricopa Association of Governments (MAG) region. The recommendations contained in this report will be considered in the development of the Regional Transportation Plan (RTP), which will provide a policy framework to guide multi-modal transportation investments over the next twenty years.

High capacity transit encompasses several different technologies, each designed with different operating characteristics and objectives for moving people. The focus of this study was to identify proven transit technologies that were capable of meeting the levels of travel demand projected in the MAG region while also serving several types of trips, both long-range and short distance.

The objectives of this study were to:

- Conduct a feasibility analysis of commuter rail along existing freight rail rights-of-way.
- Identify alternative high capacity transit service concepts such as light rail, express bus service, bus rapid transit or elevated rail for existing rail corridors where commuter rail is not feasible.
- Identify new alternative high capacity transit corridors.
- Create a regional high capacity transit system plan.
- Develop an action/implementation plan to identify roles and responsibilities for agencies in the MAG region.

1.1 Project Management Plan and Study Schedule

The High Capacity Transit study process was performed over the course of a 16 month timeframe. The Scope of Work for the project is divided into six milestones described below:

- **Study Initiation:** This milestone involves refining the project Scope of Work, preparation of a public involvement plan, review of past studies, and a comparison of high-capacity transit technologies.
- **Needs and Opportunities:** This milestone involves the identification of transit mode performance thresholds, development of modeling methods, and inventory of existing rail infrastructure.
- **Identification of Alternatives:** This milestone involves the determination of commuter rail feasibility, definition of the network of services, and identification of alternative high-capacity concepts.
- **Evaluation of Alternatives:** This milestone identifies costs, project ridership levels, and evaluate a range of transit alternatives, and potential corridors.

- **Regional Commuter Rail/High-Capacity Transit Plan:** This milestone will recommend a transit network, compare costs and ridership revenue, and prepare an implementation plan.

The sixth and final project milestone is the release and adoption of the High Capacity Transit Study Final Report.

1.2 Public and Agency Involvement Plan

The Public and Agency Involvement Plan (PIP) provided an overview of public involvement objectives for the MAG High Capacity Transit Study, as well as specific actions that will be carried out by the consulting team in association with MAG staff.

The High Capacity Transit Study PIP applied a three-tiered approach to optimize public participation in the planning process:

- **Listen to the community.** Gather useful information by talking with key players. The goal is to get all of the issues "on the table" early in the study process. This way, all concerns can be addressed at each stage of the High Capacity Transit Study. Stakeholder briefings were held with with nearly 30 stakeholders representing 16 organizations, agencies, and jurisdictions in Maricopa County. These meetings helped to set objectives for the study and focus areas for analysis.

- **Integrate information.** Work with local agencies to share recommendations as the study progresses. Provide interagency coordination to ensure consensus is maintained throughout the study process. The Agency Working group was formed as part of this effort to meet throughout the course of the study. The group of staff members from several cities in the MAG region provided a substantial amount of input into the Milestone reports.

- **Share information.** Provide informative, comprehensive information to the public. Showcase the public involvement process within the region. Public open houses were conducted during the Fall and Winter of 2002 to present the study to the general public and receive feedback that could be incorporated into the study recommendations.

2.0 Transportation Studies and Characteristics of High Capacity Transit

An essential part of developing the High Capacity Transit Study was identifying previous and current transportation study efforts underway in the MAG region, and incorporating important conclusions and recommendations about travel patterns, corridor conditions, and public support for transit services. Additionally, a comprehensive review of high capacity transit technologies was needed to identify technologies which could meet the projected travel patterns and demand present in the study area.

2.1 Review of Current and Previous Transportation Studies

The High Capacity Transit Study was conducted concurrently with several other transportation studies and projects. Results from these other study efforts were reviewed during the development of this study to identify ways that the High Capacity Transit Study could be coordinated with the recommendations of the studies and proposed projects. Regular working group meetings were held with the representatives developing the other studies to share results and conclusions to ensure consistency in the recommendations of several studies that will be incorporated in the Regional Transportation Plan.

Current and recent regional transportation studies studied during the development of recommendations for the MAG High Capacity Transit Study include the City of Chandler High Capacity Transit MIS, the MAG Regional Transportation Plan, the MAG Fixed Guideway Study, the Scottsdale/Tempe North/South Transit Corridor Study, the Central Phoenix/East Valley MIS, and the three area transportation studies covering various portions of the MAG region. State-wide transportation studies were also considered during the development of the MAG High Capacity Transit Study, including several passenger rail studies conducted by the Arizona Department of Transportation (ADOT).

Table 2-1 summarizes the major transportation and transit studies in the MAG region utilized as background for this study.

Table 2-1 **Previous and Ongoing Transportation and Transit Studies**

Study Name	Lead Agency	Study Objective
Arizona Passenger and High-Speed Rail Studies	ADOT	Identification of regions in the State of Arizona capable of supporting intercity or commuter rail service.
Governor's Vision 21 Plan	State of Arizona	Improve statewide transportation planning and funding allocation process.
Regional Transportation Plan	MAG	Outline regional transportation improvements and funding allocations for all modes of transportation.

Study Name	Lead Agency	Study Objective
Commuter Rail Demonstration Project	Valley Metro/RPTA	Asses demand for commuter rail service on two freight railroad corridors in the MAG region.
Express Bus Study	City of Phoenix & Valley Metro/RPTA	Identify ways to enhance express bus services and increase ridership.
Central Phoenix/East Valley MIS	Phoenix/Tempe/Mesa	Develop a fixed-guideway transit system in the central portion of the MAG region.
MAG Fixed Guideway Study	MAG	Analyze several different high capacity transit technologies and possible corridors for high capacity transit service.
Systemwide Transit Planning Study	MAG	Determine if high capacity transit services are appropriate in the MAG region given future travel demand and population growth.
Scottsdale/Tempe North/South Transit Study	City of Scottsdale City of Tempe	Identify a new high capacity transit corridor linking Tempe and Scottsdale with light rail or bus rapid transit technology.
Transit Plan Update	City of Chandler	Assess short-term transit needs in Chandler and adjacent communities.
Chandler High Capacity MIS	City of Chandler	Identify possible high capacity transit corridors linking Chandler to adjacent cities.
Regional Transit Study	Regional Public Transit Authority	Full assessment of local transit services in the MAG region in order to meet future projected growth.
Grand Avenue Northwest Corridor	MAG	Improve traffic flow on Grand Avenue without the construction of a new freeway or expressway.
Northwest Area Transportation Study	MAG	Identify multi-modal transportation needs in the northwestern portion of the MAG region.
Southwest Area Transportation Study	MAG	Identify multi-modal transportation needs in the southwestern portion of the MAG region.
Southeast Maricopa/Northern Pinal County Area Transportation Study	MAG	Identify multi-modal transportation needs in the southeastern portion of the MAG region.
Central Phoenix/East Valley MIS	Cities of Phoenix, Glendale, Tempe, and Mesa	Identify a high capacity transit corridor linking central Phoenix with Glendale, Tempe, and Mesa.
East-West Mobility Study	MAG	Enhance capacity of arterials streets in the northern portions of Phoenix, Scottsdale and Glendale.

2.2 Characteristics of High Capacity Transit

A broad range of transit services and technologies exist in North America and throughout the world. Transit services can be classified into three broad categories:

- Regional Connectors – Transit services in this category provide high-speed, long-distance service within the metropolitan region, operating at scheduled speeds greater than 20 m.p.h. These services are designed to carry large numbers of passengers and serve a wide geographic area.
- Primary Trunks – Services in this category typically provide frequent service over medium to long distances at slightly lower speeds than regional connectors. These services are designed to carry a large number of passengers, in some cases more than regional connectors. However, the distance of traveled for many of these trips will be shorter in length than the average trip taken on a regional connector, with more stops and connection provdied to other transit services.
- Local Feeders – Transit services within this category provide connections between regional connectors, primary trunks, and transit centers to employment and residential destinations. Transit services identified in the earlier categories are usually unable to provide the local and sometimes door-to-door service provided by these local feeders.

Each service in these categories has a defined role to fulfill in a regional transit network. Service technologies recommended for implementation as a result of the development of the High Capacity Transit Study will likely be classified as regional connectors or primary trunks.

Five proven transit technologies were evaluated for implementation in the transit corridors identified in the High Capacity Transit Study. In addition to these proven technologies, several other existing and new technologies were studied, including Diesel Multiple Unit (DMU) vehicles. The five primary transit technologies under evaluation are:

- Commuter Rail – High-speed, long distance transit service typcially linking suburban areas to urban downtowns. Stations are placed approximately three to 10 miles apart. Trains are powered by diesel locomotives.
- Heavy Rail – These transit systems are typically found in dense urban areas. Stations are located ¼ to 1 mile apart. Must be grade-sparated from other modes of traffic, usually elevated or subway.
- Light Rail Transit (LRT) – In-street or grade separated operation of light rail vehicles. Stations are located less than 1 mile apart. More flexible than heavy rail in that this technology can operate in several configurations including at-grade in an arterial street with automobile traffic.

- Automated Guideway Transit (AGT) – Similar to light rail, but this transit system must be grade separated since the vehicles are automated and not controlled by a train operator. Variations include monorails, people movers and Skytrains.
- Bus Rapid Transit (BRT) – An enhanced bus transit service operating in arterial streets or in dedicated corridors. Levels of service equal to LRT can be achieved.

Table 2-2 illustrates the classification of each transit technology in the three transit categories identified above. Table 2-2 presents a summary of high-capacity transit technologies.

Table 2-2 Summary of Transit Service Roles

Transit Technology	Regional Connector	Primary Trunk	Branch Service
Commuter Rail	☑		
Heavy Rail	☑	☑	
Light Rail	☑	☑	☑
Automated Guideway Transit		☑	☑
Bus Rapid Transit	☑	☑	☑

Table 2-3 **Summary of High-Capacity Transit Alternatives**

Attribute	Commuter Rail	Heavy Rail	Light Rail Transit	Automated Guideway Transit	Bus Rapid Transit
					
Peak Period Headway	10 to 60 minutes	2 to 10 minutes	5 to 10 minutes	2 to 10 minutes	2 to 10 minutes
Distance Between Stations	2 to 10 miles	0.25 to 2 miles	0.25 to 1 mile	0.25 to 1 mile	0.25 to 5 miles
Vehicle Type	Locomotive with single or bi-level cars or multiple unit cars	Single level cars	Single level LRT cars	Single level cars attached in pairs	40 to 60 foot single compartment or articulated buses
Capital Cost per Mile	\$2 million to \$25 million	\$50 million to \$100 million (elevated) \$150 million to \$250 million (subway)	\$25 million to \$50 million (at-grade) \$50 million to \$75 million (elevated)	\$50 million to \$100 million	\$0.5 million to \$6 million (Express bus) \$0.5 million to \$2 million (BRT Lite) \$8 million to \$14 million (BRT busway)
Average Passenger Capacity per Vehicle	100 to 200 passengers	200 passengers	50 to 150 passengers	50 to 100 passengers (regional service) 10 to 50 passengers (locational services)	40 to 100 passengers
Passenger Capacity per Hour	4,000 to 10,000 passengers	12,000 to 30,000 passengers	5,000 to 10,00 passengers	5,000 to 10,000 passengers (regional) 1,000 to 5,000 passengers (locational)	1,000 to 2,000 passengers (express bus) 3,000 to 7,000 passengers (BRT Lite, busway)
Power Source	Diesel locomotives or overhead eletric power	Electrified 3rd rail	Overhead electric wires	Electric	Diesel or LNG bus
Technology Advantages	Proven technology High speed service	Can transport high number of riders Frequent service	Most flexible rail technology Lower cost than heavy rail	No driver required Frequent service Can meet demand of passenger surges	Lowest capital cost Most flexible to expand and change alignments
System Limitations	Can only operate in rail corridors All day operations costly	Must be grade separated Needs large passenger base to be cost-effective	May require arterial street widening	Must be grade separated	May require arterial street widening

2.3 Transit Amenities

The Federal Transit Administration (FTA) has researched the impacts of improved rider amenities upon transit ridership. A report produced by the Transportation Research Board (TRB) for the FTA in 1999 examined the influence of user amenities on ridership and ways for local transit providers to select the correct amenities to meet the needs of their ridership base. Improved amenities were found to create a more positive view of transit services and attract new transit riders. However, the functionality of amenities was as important as the presence of the amenities. Poorly designed or unneeded amenities were seen more as a waste of money than as system improvements. The type of amenities most likely to attract riders varies depending upon the type of rider utilizing the service, the length of wait for vehicles, average passenger trip length, and the environmental characteristics of the region.

Commuter rail stations can have the most amenities as a result of the longer station wait times. Heavy rail, LRT, AGT, and BRT stations usually do not provide the same level of amenities present at commuter rail stations. These forms of high capacity transit systems provide more frequent service, with two to 15 minute headways, making station wait times for riders usually no longer than 15 minutes. The shorter wait times for riders at these stations reduce the need for additional amenities. Most riders would not be able to utilize and enjoy the same amenities offered at commuter rail station without missing their train.

The amenities and features found on high capacity transit vehicles can improve the perception potential riders have about the quality of service provided. Similar to the patterns for station amenities, vehicle amenities can vary depending upon the average trip length for riders and the type of riders using the service.

Long distance trips necessitate a certain set of amenities that should be provided for riders. Most commuter rail vehicles offer upholstered seats with high backs, restrooms, and large windows for passengers to view the passing scenery. Riders may also be attracted by the presence of power outlets for laptop computers and desk workspaces. These amenities can allow riders to be more productive with their commute time.

On-board amenities for other high capacity transit vehicles providing shorter distance trips are equally important. Interior improvements include better lighting, larger windows, and upholstered seats. Innovative exterior designs are also helpful in attracting riders. Both vintage and futuristic designs can attract riders to try the transit system. Vintage vehicles present an opportunity to connect with the past and make riders feel nostalgic. Futuristic designs imply speed and fast service, attracting riders who want to travel and reach their destinations quickly and on time.

3.0 High Capacity Transit Preliminary Thresholds and Corridor Assessment

The purpose of this section is to provide a profile of socio-economic and travel demand data for several possible high-capacity transit corridors within the MAG region. This data will be compared to data collected from other high capacity transit corridors located in major cities throughout North America. Three transit technologies were selected for inclusion in a peer-group review of transit systems. The three technologies were commuter rail, light rail transit (LRT), and bus rapid transit (BRT). These technologies were selected because of their prevalence in North America and their potential appropriateness for implementation in the MAG region. Six systems were selected from each technology for a general peer system review of operating characteristics. Three of these six systems were then included in a detailed comparison, which involved the collection of socio-economic data along the transit corridors. Table 3-1 illustrates the criteria selected for both the general and detailed peer group reviews.

Table 3-1 **Peer Group Review Data**

General Criteria	Detailed Criteria
Line Length	Total Corridor Population
Number of Stations	Corridor Population Density
Daily Riders	Total Corridor Employment
Year of Inception	Corridor Employment Density
Passenger Cars per Train (commuter rail only)	Number of Employment Centers (greater than 50 employees per acre)
Type of Operation (contract or in-house, commuter rail only)	Transit Dependant Households
Weekday Span of Service	Average Trip Length
Trips per Day/Peak Frequency	Freeway Lane Miles per 1,000 Residents
Weekends Trips/Off Peak Frequency	Percentage of Congested Freeway Lane Miles
Annual Revenue Service Hours	Vehicle ADT on Parallel Corridors
Operating Cost per Passenger Mile	Major Transportation Nodes Located in the Corridor
Capital Cost (year of expenditure dollars)	Major Activity Centers Located in the Corridor

The remaining technologies, heavy rail, automated guideway transit (AGT), and diesel multiple unit (DMU) trains were not included in the peer review. Heavy rail systems require a large amount of capital investment and population and employment densities, which exceed those projected for the MAG region. AGT and DMU systems will still be considered for implementation in the MAG region. However, the relative lack of peer systems for these two technologies operating in North America limited the effectiveness of including AGT and DMUs in the peer group review.

3.1 Peer Group Transit System Review

Table 3-2 lists the six transit systems for each of the three technologies included in the peer group review. Operating data for the year 2000 was collected about each of these transit systems. The three transit systems for each technology listed in bold type were included in a detailed peer group review. This detailed review involved the collection of demographic and mobility data for corridors in which these system operate. The operating data for each system is presented in Table 3-3 through Table 3-5 on the following pages.

Table 3-2 **General Peer Group Review Transit Systems**

Commuter Rail	Light Rail	Bus Rapid Transit
Los Angeles - Metrolink	**Los Angeles - Green Line**	**Los Angeles - Metro Rapid Line**
San Diego - Coaster	**San Diego - Blue Line (Mission Valley)**	**Miami – South Miami-Dade Busway**
San Jose - Altamont Commuter Express	**Dallas - Red and Blue Lines**	**Pittsburgh – South, East, and West Busways**
Dallas - Trinity Railway Express	Denver - Central and Southwest Lines	Vancouver – Richmond to Vancouver Rapid Bus
Toronto – Lakeshore East Line	San Jose – VTA Light Rail	Ottawa – Transitway
Chicago – South Shore Line	St. Louis – Metrolink	Washington DC – Dulles Airport Corridor BRT

Exhibit 3-1 illustrates the various population densities present in each of the peer group corridors.

Exhibit 3-2 illustrates the employment densities for the same corridors.

Table 3-3 Commuter Rail Peer Group Operating Data

Criteria	Los Angeles Metrolink - Inland Empire to Orange County Line	San Diego Coaster	San Jose Altamont Commuter Express	Dallas Trinity Railway Express	Chicago Northern Indiana Commuter Transportation District South Shore Line	Toronto Go Transit Lakeshore East Line
						
Line Length (miles)	59	43	82	37	90	42
Number of Stations	11	8	9	10	20	10
Daily Riders	2,930	4,300	3,317	5,900	12,800	40,715
Year of Inception	1995	1995	1998	2000	1990	1967
Passenger Cars per Train	3-5	4-5	3	2-6	5-6	3-4
Type of Operation	Contract	Contract	Contract	Contract	In-House	In-House
Weekday Span of Service	5:00 AM to 8:00 PM	5:20 AM to 7:45 PM	4:15 AM to 9:00 AM and 4:15 PM to 6:45 PM	5:00 AM to 12:30 AM	4:00 AM to 2:30 AM	5:50 AM to 1:00 AM
Trips per Day	6 inbound/6 outbound	11 inbound/11 outbound	3 inbound/3 outbound	29 inbound/27 outbound	18 inbound/19 outbound	30 inbound/29 outbound
Trips per Weekend Day	None	4 inbound/4 outbound	None	18 inbound/17 outbound	9 inbound/9 outbound	18 inbound/17 outbound
Annual Revenue Service Hours	22,267	24,482	11,776	17,206	80,113	262,000
Operating Cost per Passenger Mile	$0.26	$0.33	$0.36	$1.44	$0.28	$0.12
Initial Capital Cost (Year of expenditure dollars)	$83.5 million	$568 million	$56 million	$62.8 million	$16.8 million	$24 million

Operating Data Source: 2000 National Transit Database
Ridership Data for 2001. Data obtained from transit agencies
Schedules, stations, length, and capital cost data source: Individual transit agencies
The capital cost of the San Diego Coaster system includes the $406 million cost for purchasing the tracks and right of way from Sante Fe Depot in downtown San Diego to the northern San Diego County border
The current commuter rail operation of the Chicago South Shore line began in 1990. Intercity rail operations have occurred since 1904
The capital cost of the Chicago South Shore Line was for the purchase of the existing passenger rail operations and track rights in 1990
The capital cost of Trinity Railway Express is for the initial 10-mile segment between Dallas and Irving
The revenue service hours and operating cost per passenger mile for the GO Transit Lakeshore Line is for the entire GO commuter system
The Trinity Railway Express recently expanded service in 2002. The revenue service hour data is for 2000 when the TRE utilized shorter rail diesel cars for service. This means that this data does not match the current service provided

Table 3-4	Light Rail Peer Group Operating Data

Criteria	Los Angeles MTA Green Line	San Diego Trolley Blue Line (Santa Fe Depot to Mission Valley)	Dallas DART Blue and Red Lines	Denver RTD Central and Southwest Lines	St. Louis Metrolink	San Jose VTA
						
Line Length (miles)	20.0	9.3	20.0	14.0	34.4	28.0
Number of Stations	14	13	22	20	27	47
Daily Riders	27,500	22,295	37,680	22,460	42,380	25,570
Year of Inception	1995	1997	1996	1994	1993	1987
Passenger Cars per Train	2-3	4-5	4-6	2-4	2-6	3-6
Span of Service	3:45 AM to 2:00 AM	4:00 AM to 2:00 AM	5:00 AM to 1:00 AM	4:00 AM to 1:00 AM	5:00 AM to 3:00 AM	24 Hours
Peak Frequency	6-10 minutes	7-15 minutes	10 minutes	5-10 minutes	6-10 minutes	10 minutes
Off-Peak Frequency	15-20 minutes	15-30 minutes	15 minutes	15-30 minutes	10-30 minutes	10-30 minutes
Annual Revenue Service Hours	195,998	329,385	152,885	108,187	101,405	163,350
Operating Cost per Passenger Mile	$0.29	$0.17	$0.55	$0.40	$0.21	$1.07
Initial Capital Cost (Year of expenditure dollars)	$900 million	$223 million	$860 million	$292.3 million	$464 million	$725 million

Operating Data Source: 2000 National Transit Database
Ridership Data for 2001. Data obtained from transit agencies
Schedules, stations, length, and capital cost data source: Individual transit agencies
Annual revenue hours and operating cost per passenger mile for MTA Green Line includes Blue Line operations
Annual revenue hours and operating cost per passenger mile for San Diego Trolley is for both the Blue and Orange lines
The capital cost for the San Diego Trolley is the 6 mile portion from Old Town Transportation Center to Mission Valley Terminus
The capital cost for St Louis Metrolink is for the initial 17 miles of the system

Table 3-5 Bus Rapid Transit Peer Group Operating Data

Criteria	Los Angeles MTA Rapid Bus - Wilshire/Whittier Line	Miami South Miami-Dade Busway	Vancouver Richmond to Vancouver 98 B Line	Pittsburgh South, East & West Busways	Ottawa Transitway	Washington D.C. Dulles Corridor
						
Line Length (miles)	25.7	8.5	11.0	16.1	32.3	22.0
Number of Stations	30	16	38	26	30	8
Daily Riders	28,207	11,967	20,000	47,000	120,000	10,000
Year of Inception	2000	1997	2001	1977, 1983, 2000	1983	2001
Bus Size	40 foot	40 foot & mini bus	60 foot	40 foot	40 foot	40 foot
Location of Operation	Arterial street with mixed flow traffic	At-grade exclusive busway	Arterial street with mixed flow traffic	Grade separated busway	Grade separated busway	Highway with mixed flow traffic
Span of Service	4:00 AM to 1:30 AM	5:30 AM to 1:00 AM	4:00 AM to 1:00 AM	5:15 AM to 12:00 AM	4:00 AM to 2:00 AM	5:30 AM to 12:30 AM
Peak Frequency	2-6 min	3-5 min	5-6 min	10-15 min	10 min	60 min
Off-Peak Frequency	10-20 min	10-15 min	7-15 min	20-30 min	20-30 min	60 min
Annual Revenue Service Hours	185,700	n/a	73,000	n/a	n/a	n/a
Operating Cost per Passenger Mile	n/a	n/a	n/a	n/a	n/a	n/a
Initial Capital Cost (Year of expenditure dollars)	$5.01 million	$60 million	$30 million	$415 million	$420 million	$175 million

Operating Data Source: The respective transit agencies operating the BRT service
Ridership Data for 2001. Data obtained from transit agencies
Schedules, stations, length, and capital cost data source: Individual transit agencies
Annual Revenue Service Hours are not available for all systems due to interlining of multiple routes along the corridors
Operating Costs per Passenger Mile are not available for specific bus lines

Exhibit 3-1 **Population Densities for Peer Group Corridors**

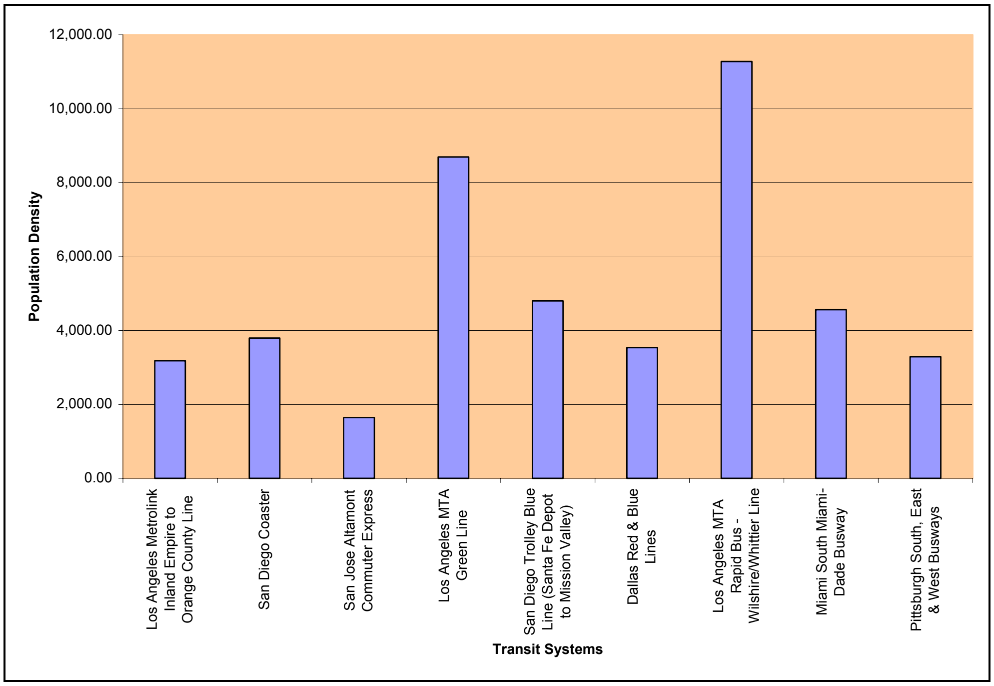
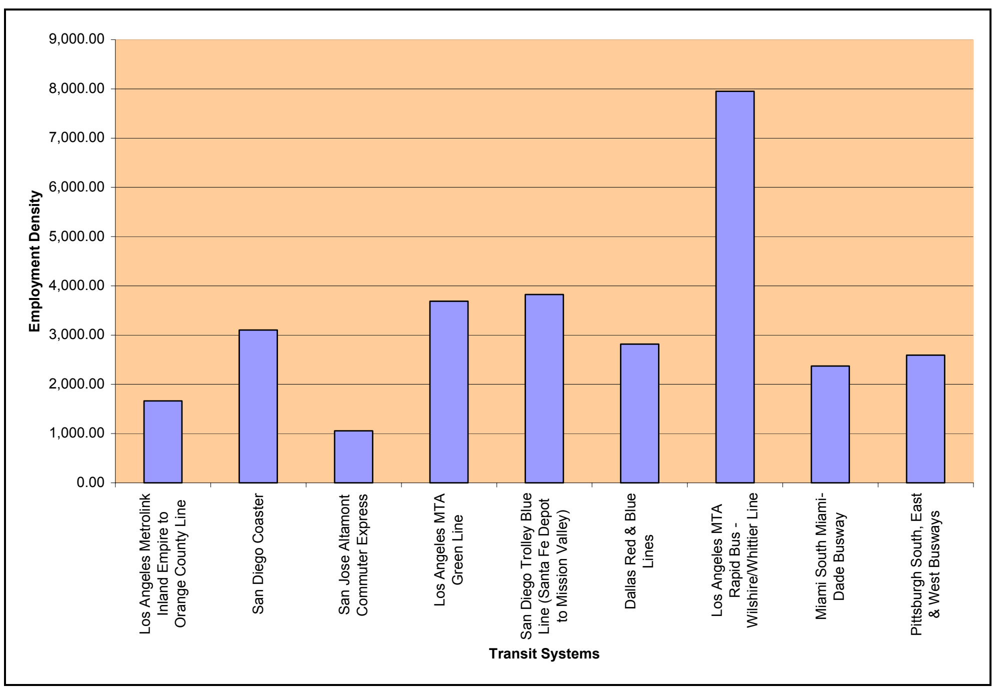


Exhibit 3-2 **Employment Densities for Peer Group Corridors**



3.2 Analysis of Peer Group Data

The three peer group systems selected for inclusion in the detailed data review possess a wide variety of population and employment densities. Specific patterns emerging from the data include:

- Commuter rail systems selected in this peer group review are capable of maintaining successful operations in corridors with lower population and employment densities that what is present in light rail and bus rapid transit (BRT) corridors.
- Each light rail or BRT system serves a minimum of one employment center (greater than 50 employees per acre) while two of the selected commuter rail systems serve corridors with more dispersed employment centers and no census tracts with greater than 50 employees per acre.
- All but one transit system operates within a metropolitan region with over 50 percent of the region's freeway lanes miles extremely or severely congested as determined by the Texas Transportation Institute, a nationally-known transportation research organization which produces reports on automobile congested each year. The only metropolitan region with a percentage below one half was the Dallas region with 48 percent of the region's freeway lane miles congested.
- Average trip lengths for commuter rail systems are a minimum of 25 miles. These averages are at least four and as many as nine times as long as the average trip lengths for light rail. Information collected about the Los Angeles Rapid Bus service suggests that average trip lengths on BRT systems are similar to those on light rail systems.

The following minimum values have been observed in the corridors studied for each of the three transit technologies:

Commuter Rail

- Population Density – 3,000 persons per square mile
- Employment Density – 1,000 persons per square mile
- Average Trip Length – 25 miles
- Daily Vehicle Trips on Parallel Corridors – 100,000 vehicles per day

Light Rail

- Population Density – 3,000 persons per square mile
- Employment Density – 2,500 persons per square mile
- Average Trip Length – 5 miles
- Daily Vehicle Trips on Parallel Corridors – 75,000 vehicles per day

Bus Rapid Transit

- Population Density – 3,000 persons per square mile
- Employment Density – 2,000 persons per square mile
- Average Trip Length – 7 miles
- Daily Vehicle Trips on Parallel Corridors – 41,000 vehicles per day

3.3 MAG Regional Transit Corridors Comparison

Sixteen corridors were initially selected for inclusion in the data collection effort for the MAG region. A single major freeway, street, or rail line was selected as the centerline for each corridor. However, these specific alignments were designed to represent all parallel alignments in the corridor including arterial streets, freeways, rail lines, and non-traditional transportation corridors such as canals or power-line easements. Individual alignments were selected to simplify the data collection effort and the presentation of the results from the modeling activities. An examination of the possible high capacity transit alignments within each corridor will be performed in a later task.

These corridors were developed from three sources:

1. Current and recently completed major transportation studies in the MAG region.
2. Suggestions of agency representatives in the stakeholder interviews.
3. Existing and future demographics and travel patterns in the MAG region.

The corridors developed using these sources were numerous, and in many cases, the corridors overlapped or served the same markets. As a solution to this issue, multiple parallel corridors were combined or modified so that the various rail, arterial street, freeway or flood control channel rights of way could easily map to a specific major corridor.

The corridors were grouped into three categories based upon their travel orientation. Table 3-7 lists the sixteen corridors included within this data collection effort.

Table 3-7 **MAG Region Transit Study Corridors**

Corridor	Category	Limits
Burlington Northern Santa Fe Railway	Radial	Downtown Phoenix to Maricopa County Line
Union Pacific Railway Southeast	Radial	Downtown Phoenix to Maricopa County Line
Union Pacific Railway South	Radial	Downtown Phoenix to Maricopa County Line

Corridor	Category	Limits
Interstate 10 (southeast)	Radial	SR-51/SR-202 Interchange to Maricopa County Line
Union Pacific Railway Yuma	Radial	Downtown Phoenix to Buckeye
State Route 51	North-South	Loop 101 to I-10/I-17 Interchange
Loop 101	North-South	Union Pacific Yuma to 75th Avenue
Interstate 17	North-South	Maricopa County Line to terminus at I-10
Scottsdale Road	North-South	Cave Creek Road to Chandler Boulevard
Loop 303	North-South	Grand Avenue to Union Pacific Yuma
Power Road	North-South	Williams Field to McDowell Road
Bell Road	East-West	Sunrise Boulevard to Loop 101
Camelback Road	East-West	Loop 101 (West Valley) to Loop 101 (East Valley)
Glendale Avenue	East-West	Grand Avenue to 56th Street
Main Street	East-West	I-10 to Old West Highway
Chandler Boulevard/Williams Field	East-West	Power Road to Ray Road

Data about population, employment, transit dependency, travel patterns, and congestion levels was collected within a five mile radius for each of the 16 corridors. This study radius is consistent with the radius of the study areas for transit systems included in the peer group review.

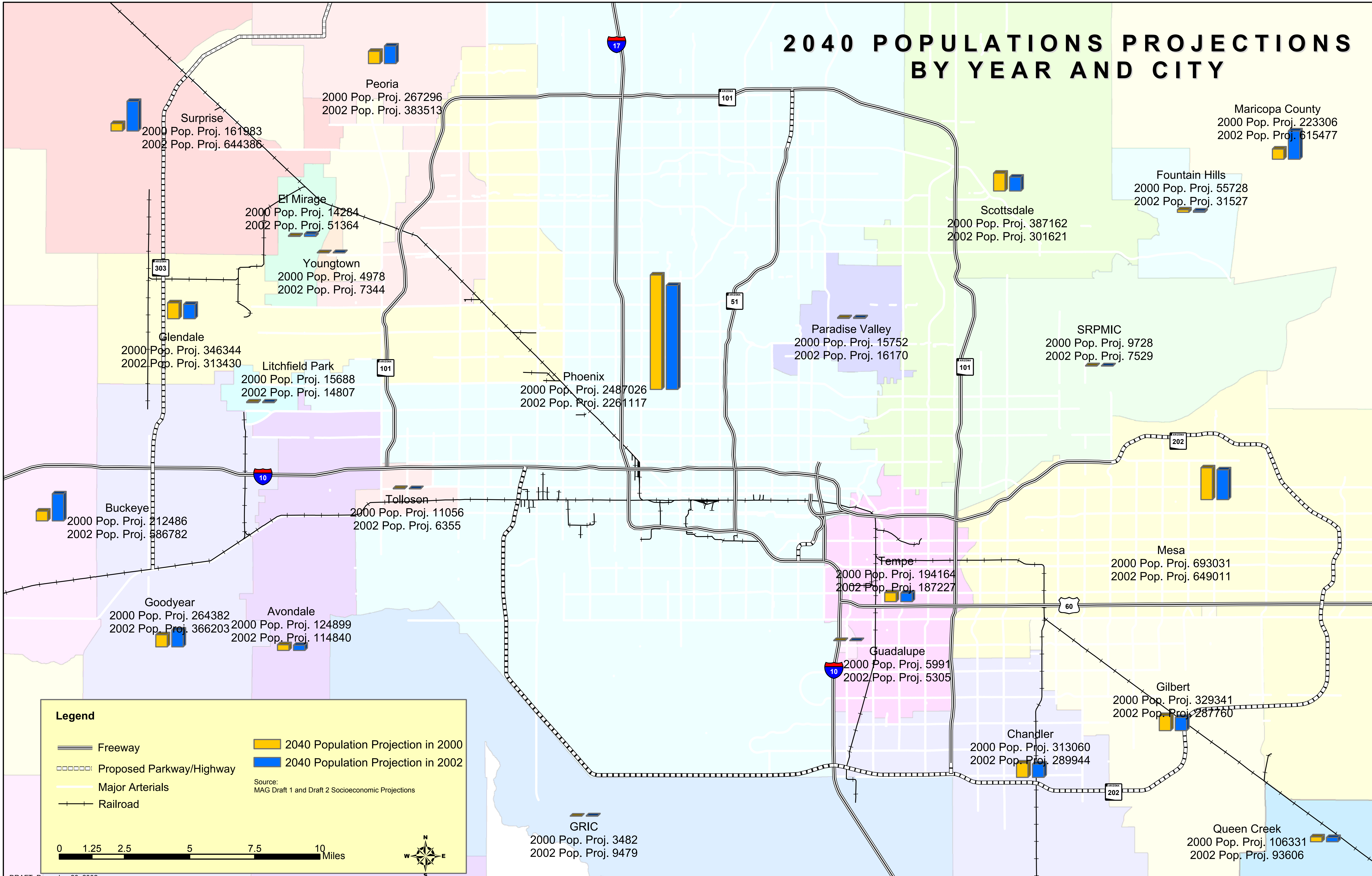
The population and employment forecasts collected for these corridors were revised by MAG during the development of the High Capacity Transit Study. The revised population projections were included in the development of Milestone 5, and resulted in increases to the overall Year 2040 population in the MAG region to 7.4 million residents, compared to a previous Year 2040 buildout population of approximately six million residents (Source: Draft 2 Socioeconomic Projections). The majority of this new growth occurs in the western MAG region, specifically in cities such as Buckeye, Surprise and Goodyear. Several areas and municipalities in the MAG region have seen a reduction in future population levels as a result of the new projections, specifically in the East Valley and portions of Phoenix, largely as a result of land use plan changes incorporated into the revised forecasts.

Major changes in selected cities are noted below and represent the percentage change from the previous forecasts:

- Buckeye population increase of 276 percent

- Surprise population increase of 298 percent
- El Mirage population increased by 260 percent
- Mesa population reduced 6.4 percent
- Queen Creek population reduced 12 percent
- Gilbert population reduced 13 percent
- Chandler population reduced by 7.5 percent

Exhibits 3-3 and 3-4 illustrate the change in the projected population and employment in each city between the previous regionally adopted population estimates and the revised draft estimates. Exhibits 3-5 and 3-6 illustrate the projected increase population and employment densities from 2002 to 2040 by Traffic Analysis Zone (TAZ).


2040 POPULATIONS PROJECTIONS
BY YEAR AND CITY
Peoria
2000 Pop. Proj. 267296
2002 Pop. Proj. 383513
Surprise
2000 Pop. Proj. 161983
2002 Pop. Proj. 644386
El Mirage
2000 Pop. Proj. 14284
2002 Pop. Proj. 51364
Youngtown
2000 Pop. Proj. 4978
2002 Pop. Proj. 7344
Glendale
2000 Pop. Proj. 346344
2002 Pop. Proj. 313430
Litchfield Park
2000 Pop. Proj. 15688
2002 Pop. Proj. 14807
Phoenix
2000 Pop. Proj. 2487026
2002 Pop. Proj. 2261117
Paradise Valley
2000 Pop. Proj. 15752
2002 Pop. Proj. 16170
Scottsdale
2000 Pop. Proj. 387162
2002 Pop. Proj. 301621
Maricopa County
2000 Pop. Proj. 223306
2002 Pop. Proj. 615477
Fountain Hills
2000 Pop. Proj. 55728
2002 Pop. Proj. 31527
SRPMIC
2000 Pop. Proj. 9728
2002 Pop. Proj. 7529
Buckeye
2000 Pop. Proj. 212486
2002 Pop. Proj. 586782
Tolleson
2000 Pop. Proj. 11056
2002 Pop. Proj. 6355
Mesa
2000 Pop. Proj. 693031
2002 Pop. Proj. 649011
Tempe
2000 Pop. Proj. 194164
2002 Pop. Proj. 187227
Goodyear
2000 Pop. Proj. 264382
2002 Pop. Proj. 366203
Avondale
2000 Pop. Proj. 124899
2002 Pop. Proj. 114840
Guadalupe
2000 Pop. Proj. 5991
2002 Pop. Proj. 5305
Gilbert
2000 Pop. Proj. 329341
2002 Pop. Proj. 287760
Chandler
2000 Pop. Proj. 313060
2002 Pop. Proj. 289944
GRIC
2000 Pop. Proj. 3482
2002 Pop. Proj. 9479
Queen Creek
2000 Pop. Proj. 106331
2002 Pop. Proj. 93606
17
101
51
303
10
202
60
Legend
Freeway
Proposed Parkway/Highway
Major Arterials
Railroad
2040 Population Projection in 2000
2040 Population Projection in 2002
Source:
MAG Draft 1 and Draft 2 Socioeconomic Projections
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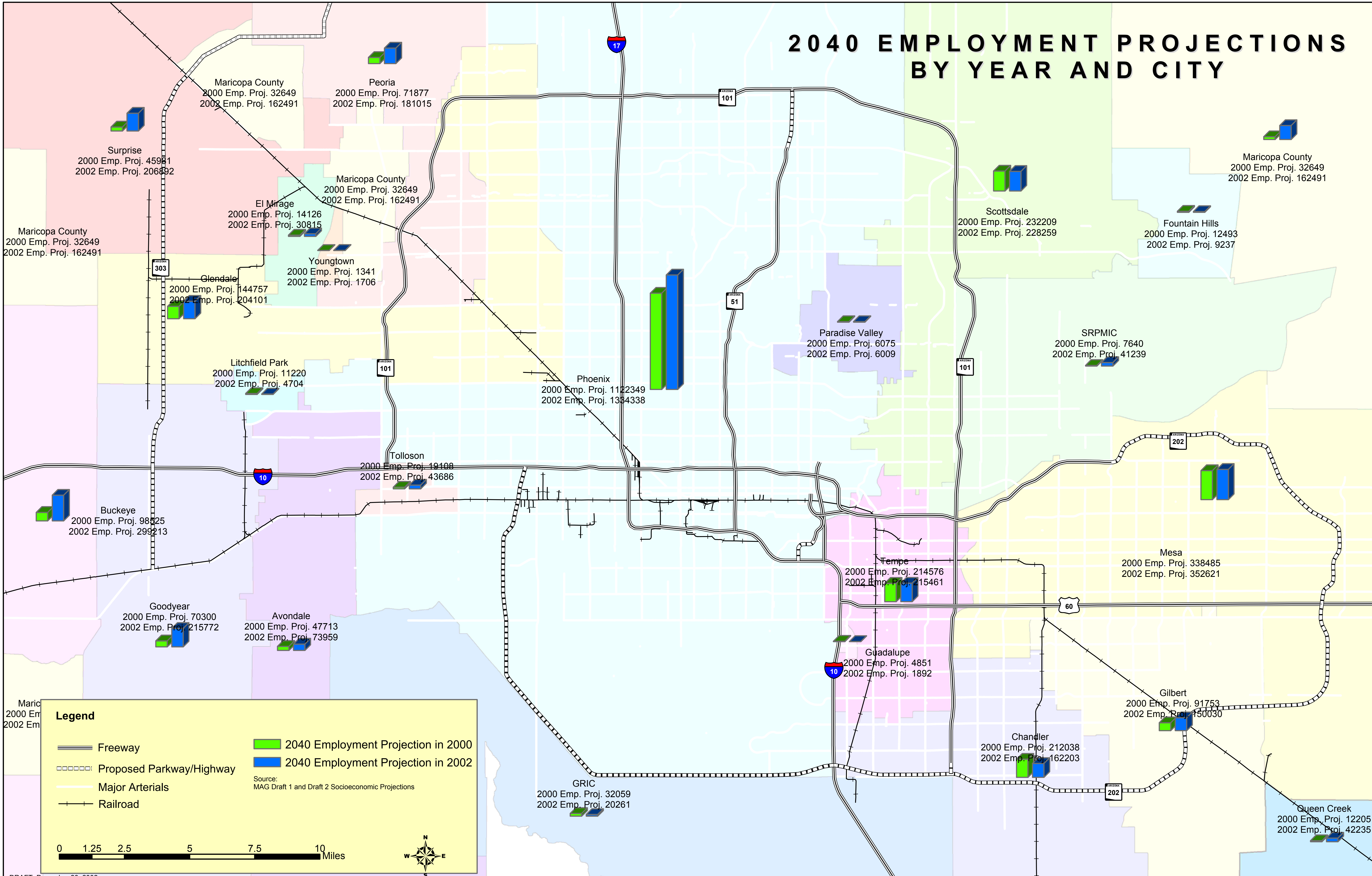
DRAFT: December 26, 2002



2040 EMPLOYMENT PROJECTIONS
BY YEAR AND CITY
Maricopa County
2000 Emp. Proj. 32649
2002 Emp. Proj. 162491
Peoria
2000 Emp. Proj. 71877
2002 Emp. Proj. 181015
Surprise
2000 Emp. Proj. 45981
2002 Emp. Proj. 206892
Maricopa County
2000 Emp. Proj. 32649
2002 Emp. Proj. 162491
El Mirage
2000 Emp. Proj. 14126
2002 Emp. Proj. 30815
Maricopa County
2000 Emp. Proj. 32649
2002 Emp. Proj. 162491
Youngtown
2000 Emp. Proj. 1341
2002 Emp. Proj. 1706
Glendale
2000 Emp. Proj. 144757
2002 Emp. Proj. 204101
Scottsdale
2000 Emp. Proj. 232209
2002 Emp. Proj. 228259
Maricopa County
2000 Emp. Proj. 32649
2002 Emp. Proj. 162491
Fountain Hills
2000 Emp. Proj. 12493
2002 Emp. Proj. 9237
Paradise Valley
2000 Emp. Proj. 6075
2002 Emp. Proj. 6009
SRPMIC
2000 Emp. Proj. 7640
2002 Emp. Proj. 41239
Litchfield Park
2000 Emp. Proj. 11220
2002 Emp. Proj. 4704
Phoenix
2000 Emp. Proj. 1122349
2002 Emp. Proj. 1334338
Tolleson
2000 Emp. Proj. 19108
2002 Emp. Proj. 43686
Buckeye
2000 Emp. Proj. 98525
2002 Emp. Proj. 299213
Mesa
2000 Emp. Proj. 338485
2002 Emp. Proj. 352621
Tempe
2000 Emp. Proj. 214576
2002 Emp. Proj. 215461
Goodyear
2000 Emp. Proj. 70300
2002 Emp. Proj. 215772
Avondale
2000 Emp. Proj. 47713
2002 Emp. Proj. 73959
Guadalupe
2000 Emp. Proj. 4851
2002 Emp. Proj. 1892
Gilbert
2000 Emp. Proj. 91753
2002 Emp. Proj. 150030
Chandler
2000 Emp. Proj. 212038
2002 Emp. Proj. 162203
GRIC
2000 Emp. Proj. 32059
2002 Emp. Proj. 20261
Queen Creek
2000 Emp. Proj. 12205
2002 Emp. Proj. 42235
17
101
303
51
101
101
10
202
60
10
202
Legend
Freeway
Proposed Parkway/Highway
Major Arterials
Railroad
2040 Employment Projection in 2000
2040 Employment Projection in 2002
Source:
MAG Draft 1 and Draft 2 Socioeconomic Projections
0 1.25 2.5 5 7.5 10 Miles
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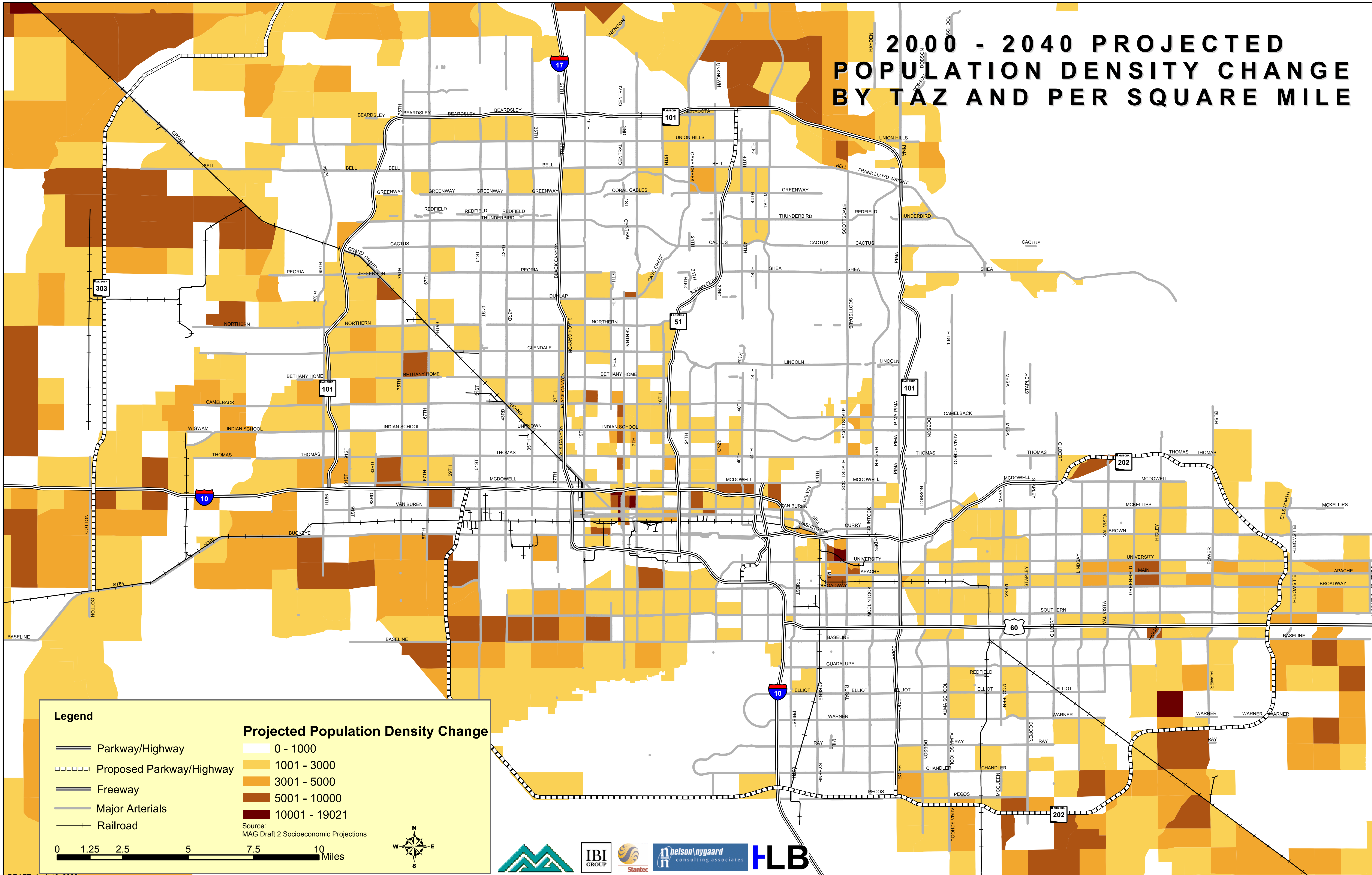

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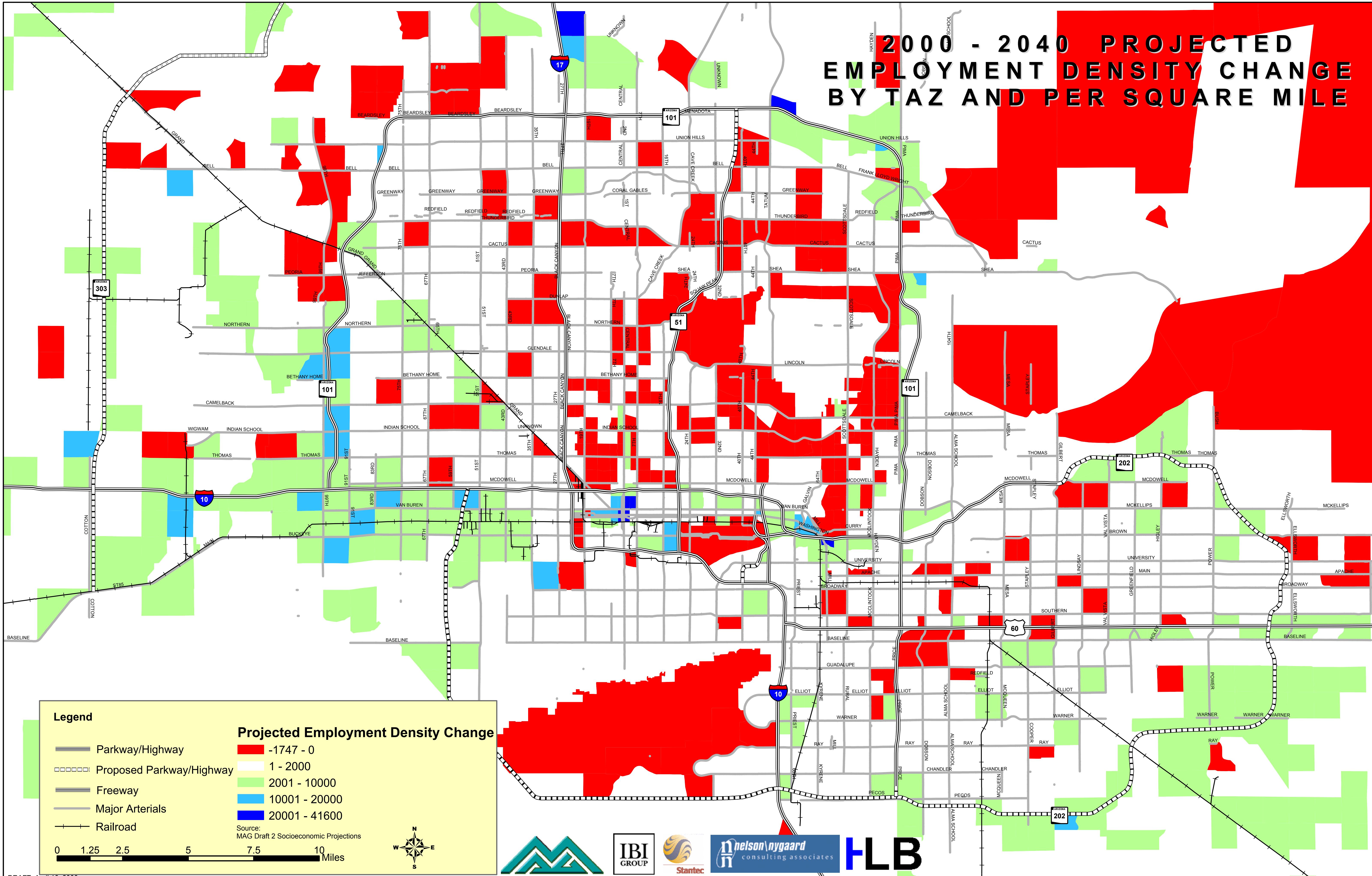
2000 - 2040 PROJECTED
EMPLOYMENT DENSITY CHANGE
BY TAZ AND PER SQUARE MILE
Legend
Parkway/Highway
Proposed Parkway/Highway
Freeway
Major Arterials
Railroad
Projected Employment Density Change
-1747 - 0
1 - 2000
2001 - 10000
10001 - 20000
20001 - 41600
Source:
MAG Draft 2 Socioeconomic Projections
0 1.25 2.5 5 7.5 10 Miles
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HLB
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4.0 Modeling and Forecasting Scenarios

The forecasting methodology used to estimate the potential use of high capacity transit services is intended to provide projections of future ridership and revenues for a range of high capacity transit alternatives, and provide measures and factors to allow the determination of the transportation benefits and impacts. Given the scope and objectives of this study, the forecasts were prepared at a level-of-detail and rigor consistent with conceptual planning and feasibility assessment. This provides sufficient accuracy to determine the relative differences among alternatives and identify those alternatives where significant promise exists to assist in developing a general long-term high capacity strategy.

The starting point for this study was a long list of high demand corridors in the MAG region, with the technology and service concepts for the alternatives to be tested to be determined as part of the study. Important elements of the forecasting approach therefore includes flexibility, quick turnaround and the ability to assess a wide range of innovate and traditional transportation solutions. The approach must also have the ability to consider the full transit potential of a corridor given possible changes in land use mix, urban design and transit supportive policies. However, a difficulty with a traditional transportation modeling approach is it is solely based upon existing travel behavior and influences, which strongly favor the private automobile. It is therefore very difficult to predict the potential of totally new transit modes such as commuter rail. A detailed modeling approach also introduces significant technical and time delay risks and has large cost implications.

Given the above, a strategic forecasting approach was proposed, reflecting the uncertainty of introducing a new mode and the very possible change to transit use propensities associated with the implementation of more transit oriented development in the corridors. First, more than one forecasting technique was proposed to forecast ridership on high capacity transit alternatives to help bracket the range in demand and to provide an independent crosscheck of the respective estimates. Second, while the process will be sensitive to level-of-service of the high capacity transit alternatives, it will rely more heavily on market penetration rates and experiences in other peer cities with commuter rail/LRT to help determine the potential transit usage within the MAG demand context. These forecasting techniques will also be consistent with travel demand forecasts from the MAG transportation model and MAG population and employment projections.

As described in greater detail below, three independent forecasting procedures will be applied to help bracket range in future demand:

Sketch Plan Model – a “sketch planning” tool developed by MAG to provide estimates for LRT alternatives. The process is based on LRT trip rates that are applied to demographic and employment data within in the alternatives catchment area. This process was applied to the BRT/LRT alternatives generated in this study.

Direct Demand Model - a simplified model process based on empirical data obtained from other commuter rail facilities. It is designed specifically for estimating ridership on new commuter rail lines directly from socio-economic data. It was applied to estimate ridership on commuter rail alternatives in this study;

Simplified Regional Model Approach –use of existing model runs from the MAG model with a simplified transit modal split update procedure used in corridors benefiting from the proposed high capacity transit improvements. Simplified methods such as travel time elasticities and the adoption of modal split targets based on penetration rates achieved in other peer cities with high capacity transit will be employed. This process will be used to estimate all study alternatives in the Recommended High Capacity Network.

With the above methods, two independent ridership estimates were developed for each alternative (simplified model for all alternatives and either the sketch or direct demand model).

4.1 Links with Other Study Tasks

The travel demand modeling methods were applied in several different areas throughout the study:

Milestone 3: Identification of Alternatives – modeling methods were applied at a very preliminary level to assist in developing the alternatives and help screen out non-promising alternatives;

Milestone 4: Evaluation of Alternatives – the direct demand and simplified/sketch planning techniques were applied to estimate ridership for the identified alternatives. The forecasts will provide information to support operational, revenue and costing analyses undertaken as part of the evaluation.

Milestone 5: Regional Commuter Rail/High-Capacity Transit Plan – the forecasts for the recommended network were updated to reflect possible changes, as the final service concept and operational characteristics are refined, following the evaluation process. The full MAG regional transportation model was also run with the recommended high capacity transit network. Commuter rail is currently not included in the MAG model, but the existing model coefficients for LRT/BRT were used as a proxy to estimate potential demand. A more sophisticated approach would be to undertake stated preference surveys to allow commuter rail to be calibrated into the model, but this is outside the scope of the study.

5.0 MAG Regional Rail Inventory

The two major freight railroad companies operating in the MAG region are the Burlington Northern Santa Fe (BNSF) and the Union Pacific (UP) Railroads. The BNSF line is a branch line originating in Williams, Arizona, entering the MAG region from the northwest near Wickenburg. The UP freight corridor is a branch of the main UP transcontinental line running through the MAG region between Palo Verde Nuclear Generating Station and Queen Creek. The portion of this line west of Palo Verde Nuclear Generating Station has been abandoned by the UP, requiring all UP freight traffic to enter the MAG region from the east via Gilbert. Two major industrial branch lines in the East Valley, the Tempe Branch and the Chandler Branch, are also operated by UP. Exhibit 5-1 on the next page provides an overview of the freight rail network within the MAG region.

5.1 Burlington Northern Santa Fe Railway

The main line of BNSF between Phoenix and Wickenburg is a single track corridor, approximately 100 feet wide, with sidings located in the right-of-way to allow for trains to pass each other. The freight line parallels Grand Avenue in this portion of its run between Phoenix and Williams. The line is operated as yard limits, a designation used to facilitate easy access for freight cars to the main track to perform industrial switching activity, creating an ancillary problem: the switching activity potentially obstructs through traffic including possible commuter trains.

The BNSF line is operated as "dark" territory, without signal enhancements. Such an operation has less capacity than a signalized line and probably would not be suitable to commuter train service in its current form; although there are some instances of commuter services operating on unsignalized rail lines. The primary concern associated with the absence of signals is the absence of notification of operating problems such as a broken rail or a stopped train, elevating the risk of accidents.

Fifty-two grade crossings are located in the corridor between Surprise and downtown Phoenix. Several of these major crossings southeast of the Loop 101 freeway are located adjacent to six-legged street intersections, complicating automobile movements and creating safety concerns. Freight train speeds along the line range from 10 to 49 mph depending upon several circumstances including yard activity and grade crossings. It should be noted that maximum speeds would likely be higher for passenger or commuter rail trains.

BNSF's operating facilities in the MAG region are near capacity, with the business base viewed as growing, requiring capital investment in a new yard facility in the near future to stay ahead of the regional demand curve. BNSF has presented the idea of potentially relocating their yard facilities to a location west of their current intermodal facility in El Mirage. The overall likelihood of this proposal has not determined.


POTENTIAL FREIGHT RAILROAD NETWORK
To Wickenburg
To Palo Verde
BNSF
Union Pacific
Union Pacific
UP Tempe
UP Chandler
GRAND
BELL
GREENWAY
THUNDERBIRD
CACTUS
PEORIA
NORTHERN
GLENDALE
BETHANY HOME
CAMELBACK
INDIAN SCHOOL
THOMAS
MCDOWELL
VAN BUREN
BUCKEYE
BASELINE
BROADWAY
SOUTHERN
ELLIOT
WARNER
RAY
CHANDLER
PECOS
QUEEN CREEK RD
17
10
10
51
60
101
101
101
202
202
303
Legend
Railroad
Parkway/Highway
Proposed Parkway/Highway
Freeway
Major Arterials
Freight Railroad
0 1.25 2.5 5 7.5 10 Miles
N
W
E
S
April 14, 2003

5.2 Union Pacific Railway

The Union Pacific Phoenix Line is single track in the MAG region with ten sidings for meeting or passing trains. The corridor right-of-way is generally 100 feet wide. Originally, the line was operated as a loop off of the main transcontinental line between Tucson and Yuma. The line segment west of Palo Verde Nuclear Generating Station was removed from service following an Amtrak derailment in 1995. With the discontinuance of through train operations on the UP Phoenix Line, all UP freight traffic enters and exits the MAG region from the east through Queen Creek.

The main track is signaled with an Automatic Block Signal System (ABS), and a dispatcher controls train movements. This signal system will accommodate higher train speeds than will "dark" territory, and arguably higher train capacity.

The UP system in the MAG Region also includes two major single track industrial leads or branches in the East Valley, the Tempe Industrial Lead and the Chandler Industrial Lead. The Tempe Industrial Branch diverges from the main track at Tempe and runs to West Chandler, a distance of approximately eight miles. The Chandler Industrial Branch diverges from the main track at McQueen Junction (Mesa) and runs to Dock, a distance of approximately twenty miles. Both the Tempe and Chandler Industrial Leads are operated as "dark" territory with a maximum speed of 20 mph.

The UP main track is comprised for the most part, of jointed rail, which is not as favorable to passenger comfort as continuously welded rail. The corridor is generally tangent, except for an area near 23rd Street west of downtown Phoenix. Also three significant curves bring system speeds down to 20 mph between 48th Street and Rural Road and 25 mph between McDonald Road and West 8th Street. Track speeds are largely influenced by the concentration of spur tracks diverging from the main track, and by curves or class of track. The track is generally maintained to Class III standards, allowing a speed of 60 mph for passenger trains.

5.3 Common Issues in Commuter Rail Operations

Over the past two decades, there has been a wave of "start-up" commuter rail operations, particularly in the western United States. Based on that experience, the following are some typical issues likely to arise in ongoing discussions of commuter rail in the MAG region including potential resolution mechanisms and lessons learned from other systems.

Ownership - Two ownership options are realistic, viable models for the MAG region:

- **Agency Purchases Line, with Railroad Remaining as Tenant** – This option allows the commuter rail agency to control operations and scheduling, likely improving operating times and schedule adherance. The negative aspect is that the agency will be responsible for all track maintenance and upgrades, increasing operating costs.

- **Agency Purchases or Leases Trackage Rights, with Railroad Remaining in Control** – Lower capital costs that purchasing the line because only the right to use the tracks is being purchased instead of the physical line. A negative aspect is that the freight rail company retains control of scheduling and operations. Freight operators will always favor their own service in terms of scheduling because it is in their best interest in terms of profitability. Agreements between the agency and the frieght operator are essential to ensure that scheduling impacts to commuter rail operations are minimized.

Successful cases of both the purchase and lease models can be found in the industry, including recent start-ups. Both models will be considered for application to the MAG region in future study phases.

Freight/Passenger Capacity Conflicts - Most of the commuter rail systems in North America operate in corridors that are shared with freight rail haulage operations, and intercity (Amtrak) passenger service. This shared-use accounts for much of the cost-effectiveness of commuter rail operations relative to other high-capacity transit systems with dedicated rights-of-way, but gives rise to several issues including control of maintenance, train dispatch, and terms of use. For the most part, infrastructure improvements are not imposed arbitrarily by the freight railroads, but make sense for a commuter operator also, as the investment often ensures better on-time performance of commuter trains.

Capacity improvements in existing freight rail corridors can be achieved by:

- Adding track, either second or third main line, or adding service tracks in areas where a number of rail customers may be located.
- Signaling improvements to improve the capacity of a line.
- Rescheduling of freight train services. In some cases, railroads have been persuaded to reschedule their services such that they do not conflict with commuter operations. For example, freight trains might be operated in non-commuter operation timeslots.

Grade Crossings - The addition of commuter rail services will cause congestion for vehicular traffic at grade crossings of railroad tracks. A service of five trains in each direction will mean that the crossing will be closed ten more times per day. For this reason, there is often public and local agency pressure to construct grade-separations as part of the commuter rail system. Grade-separations are a very high-cost item, and the addition of even a few such works in the initial construction of a commuter rail system can have significant impacts on the project's cost-effectiveness.

There are several other factors that tend to mitigate the traffic impacts of commuter rail operations, and they should all be considered when debating the inclusion of grade-separations in a project. First, for a commuter train operating at line speed, the crossing will be closed for one-half minute or less, whereas a freight train can close a grade crossing for several minutes. Second, the service will attract commuters out of their cars, thereby easing congestion on parallel facilities. While this benefit will be diffused throughout a large region, compared to the localized impacts of increased delay at grade-crossings, it nevertheless is a real benefit that should be accounted for in discussions. Finally, if commuter rail operation requires the shifting of freight trains to off-peak times, mid-day or night, there could be a significant net reduction in grade-crossing delays during peak hours, even with the new commuter trains.

Noise Impacts - Extra rail traffic will increase noise impacts on adjacent properties. Forms of noise will include the operation of the diesel locomotive and track noise, particularly when operating over jointed rail. These impacts are generally far less for commuter trains than for freight trains, due to weight, length and speed of commuter trains.

In addition, the commuter train will use its engine whistle to alert motorists of its presence approaching road grade crossings, and this is usually the most contentious noise issue in a community. The whistle noise disperses through a large area and can be a major irritant in a residential setting. Strategies currently under investigation to mitigate whistle noise include relocating horns further down on the locomotive, experimental systems where the whistle warning is directional and actuated from a stationery track-side device, and "quiet zones", establishing conditions whereby trains may pass silently through at-grade crossings. Currently, because of liability concerns, these devices and systems are not yet in common use in the United States.

Station Impacts - Stations can require a considerable amount of land, particularly if major park-and-ride facilities are provided. The stations will also generate vehicular traffic, which may have impacts on local areas. Such factors often constitute the majority of impacts related to a commuter rail operation, and consequently play a major role in the siting of stations. Resolution of such issues requires a thorough traffic impact analysis and access plan, completed in close consultation with the affected city and its residents. In discussions, the benefits of the station to the surrounding community, both as a new transportation amenity and, potentially, as a catalyst for urban revitalization and economic development, should be kept in mind as solutions to the traffic issues are developed.

Capital Needs - Three major areas requiring capital expenditures for the introduction of a new commuter rail service are infrastructure improvements, stations and attendant parking facilities, and rolling stock.

The first two of these are not moveable assets and probably require investment by a public agency. This investment may be accumulated from existing sources of funds and from state and federal agencies. Incremental local sales taxes have also been used effectively to underwrite the cost of transit projects such as commuter train operations.

The locomotives and passenger cars could be financed by similar methods. In some cases, equipment has been leased. However, leases increase operating costs and the operating fare box shortfall becomes more exaggerated. For that reason, agencies generally prefer to purchase equipment outright. Even so, the number of new commuter rail systems coming into operation in North America, has produced an after market for rolling stock, which may make leasing attractive.

Governance Structures - There are two major aspects with respect to governance structures: (1) Who will be the operating agency and (2) who will actually operate the trains. With respect to the first question, four major structures are used in the United States:

- An existing local transit agency assumes control of the commuter rail operation.
- A second approach is for the state to assume responsibility. This is largely an east-coast approach, employed by the States of New Jersey, Maryland and Connecticut. In all three cases, the state government has had a lengthy history of active involvement in rail operations.
- An existing regional transportation body to act as the commuter rail agency. This is largely a large-system, east-coast approach, used in Chicago, and New York City.
- The final alternative is to establish a specific, single-purpose entity exclusively for commuter rail operations. This option has been the most commonly used approach in recent systems, including the Southern California Regional Rail Authority (SCRRA) and the Trinity Railway Express in Texas. This approach is popular because it can combine the responsiveness of a local agency with the political/funding clout and broad outlook of a regional or state agency.

With regard to the second question, the commuter trains can be operated by authority employees, contracted to the freight rail operator, or contracted to another party. Amtrak is frequently contracted to operate commuter trains. They bring a great depth of experience, but can be expensive. For that reason, several private companies have successfully won commuter train operating contracts based on cost-competitiveness.

Maintenance of way, equipment maintenance, and dispatching services are generally contracted separately, although the train operator frequently provides these services too. As noted before in this report, the freight railroad will not relinquish control over maintenance of way, or train dispatching unless there is a line sale. Dispatching control is important. The experience in Southern California is that trains dispatched by an SCRRA contractor have higher on-time performance than is the case where the freight railroad performs the dispatching.

5.4 Feasibility Conclusions

Without major capital investment, the BNSF line is not amenable to a commuter operation. Investment would have to be made in a signal system throughout the commuter system operating envelope. In addition, as noted earlier, the main track is used as a switching lead and is not amenable to a high-speed commuter train operation commingled with heavy industrial use. At a minimum, a second main track would have to be constructed between Surprise and downtown Phoenix. As previously written, the BNSF corridor is one hundred feet wide and would accommodate a second main track and other improvements. Should service be extended to Wickenburg, some of the sidings between Surprise and Wickenburg would have to be lengthened so as to neutralize the operating and service impact on the freight operations of BNSF.

The UP line between Buckeye and Queen Creek is generally suitable for a turn-key commuter train operation. The UP's absorption of main track capacity to accommodate its freight operation is mixed but generally favorable. In the East Valley, there is little industry situated along the main track of UP and therefore, little need for switching activity. The main conflict here is the operation of six daily through freights trains between Picacho and downtown Phoenix, which could be balanced with some infrastructure investment to make a commuter operation possible. The same can be said of the switch activity on the Chandler and Tempe Industrial Leads. The West Valley industrial switching of UP is concentrated along the main track and is more absorbing of track capacity. However, it is not as concentrated as the switching needs of BNSF along its main track, and could be balanced with a small commuter train operation.

Nevertheless, over time, the signal system would need to be upgraded and sidings lengthened in the East Valley. In addition, for the sake of passenger comfort, a commuter rail agency would probably upgrade the rail to heavier continuous welded rail, and replace at least one-third of the ties. Several new storage tracks would need to be constructed to ensure separation of the freight and passenger train operations. Finally, neither the Tempe nor Chandler Branch is suitable for commuter train operations without investment in rail, ties and a signal system.

Initial contacts have been made with both BNSF and UP to inquire about each company's ability and willingness to accommodate potential commuter rail operations. BNSF has been very receptive to developing ways to accommodate commuter rail operations on their Phoenix line. In contrast, UP has not made any indication as to whether the company would be willing to accept commuter rail operations sharing their right of way with UP freight trains.

In the case of both BNSF and UP, it should be noted that the value of each line is the corridor itself, and that the corridors are used in a compatible manner with a commuter train operation.

6.0 Commuter Rail Infrastructure, Network, and Operating Characteristics

Commuter rail service in the MAG region would be implemented as a network of several corridors, providing service across the region so that someone starting a trip in Surprise would be capable of traveling to Buckeye or Mesa entirely on the commuter rail system.

Three levels of commuter rail service were examined:

- Phase 1: Start-Up/Introductory Services: limited peak hour, peak direction service composed of three trains inbound in the a.m. peak and outbound in the p.m. peak on each of the networks.
- Phase 2: Intermediate Services: Headways of 20 minutes peak hour will be examined together with limited counter-flow service. Midday service would consist of hourly trains in each direction.
- Phase 3: Full Commuter Train Operation: 15 minute headways during the peak hours and at 30 minute headways during the off-peak, with peak period 30 minute interval counter-flow services.

Each of the recent “New Starts” commuter rail operations implemented in the western United States has begun as a simple system of service primarily operating during the peak commute time periods. This operating characteristic is a result of two primary factors: cost and ridership. The implementation of commuter rail service can be costly if too much service is provided at one time. Large commuter rail operations require extensive maintenance facilities, storage areas, and additional track infrastructure. These capital items come with heavy costs which many new start commuter rail operations are unable to accommodate early in operations. These capital improvements are much more feasible and cost-effective when implemented as the commuter rail network grows.

During the initial months and years of service the commuter rail system is developing its ridership base and becoming integrated into the regional transportation network. The development of a ridership base occurs over several years, meaning that a full scale, all-day operation would be hard-pressed initially to attract enough riders to be cost-effective. A phased implementation gives the commuter rail property the opportunity to build a ridership base while maintaining lower operating costs. New service can be implemented as passenger demand warrants either with additional frequency or larger train sets.

Based upon discussions held with BNSF and UP, infrastructure enhancements required to implement commuter rail service in freight rail corridors in the MAG region have been identified. BNSF infrastructure improvements are based upon the premise that BNSF does not change its operating practices along the rail line between Phoenix and Peoria. There is a possibility of BNSF relocating its yard facilities. However, this relocation is not finalized and a conservative infrastructure requirement was assumed to account for the existing conditions.

Infrastructure requirements in the BNSF corridor are summarized in Table 6-1. UP freight corridor infrastructure requirements are summarized in Table 6-2.

Table 6-1 **BNSF Corridor Infrastructure Improvements**

Phase	Infrastructure	Phoenix to Surprise	Surprise to Wickenburg
Phase 1	Track	Second main track, one 2,000 foot siding	Lengthen siding at Wittman to 8,000 feet
	Signals	CTC recommended, not required	CTC optional
Phase 2	Track	Two additional 2,000 sidings for counter flow service	Construct 8,000 foot sidings at eight mile intervals for counter flow service
	Signals	CTC signals (if not implemented in Phase 1)	CTC signals
Phase 3	Track	A second commuter rail track three miles in length near downtown Phoenix	Construct two mile long sidings every five miles
	Signals	Signalization of the new three miles of track	Signalization of new track

Table 6-2 **UP Corridor Infrastructure Improvements**

Phase	Infrastructure	Buckeye to Downtown Phoenix	Downtown Phoenix to Tempe Junction	Tempe Junction to McQueen Junction	McQueen Junction to Queen Creek	Chandler Branch
Phase 1	Track	No improvements required	Construct second main track	Add second main track between west Mesa and McQueen	No improvements required	Upgrade track to Class 4 standards (80 mph)
	Signals	No improvements required	Upgrade signals to CTC	Upgrade signals to CTC	No improvements required	No signals required with 59 mph speed limit
Phase 2	Track	Two miles of auxiliary track for freight switching	No additional improvements required	No additional improvements required	Two new 8,000 foot sidings	Construct a 2,000 foot siding for meeting trains
	Signals	No additional improvements required	No additional improvements required	No additional improvements required	Upgrade signals to CTC	CTC signals recommended
Phase 3	Track	No additional improvements required	No additional improvements required	Add second main track between Mesa and Tempe Junction	Side tracks of two miles in length every five miles	Construct a second 2,000 foot siding

Phase	Infrastructure	Buckeye to Downtown Phoenix	Downtown Phoenix to Tempe Junction	Tempe Junction to McQueen Junction	McQueen Junction to Queen Creek	Chandler Branch
	Signals	Upgrade signals to CTC	No additional improvements required	CTC signals for new track segment	CTC signals for new track segments	Install CTC if not completed in Phase 2

6.1 Potential Station Locations

The operating characteristics of commuter rail have been documented previously in this report. With regards to station locations, the distance between stations can range from two to 10 miles depending upon travel demand and population and employment densities. These distances also help to maintain faster operating speeds, part of the attraction of commuter rail. Several possible station areas have been identified along each of the rail corridors in the MAG region. More precise locations will be determined later in this project once the network operating characteristics have been developed. There are three essential elements which will be part of a decision to locate commuter rail stations:

- Good automobile access,
- Good access for other transit services, and
- An adequate amount of available land for parking and station facilities.

At this stage, it is possible identify general station areas and the most likely set of station facilities which would be provided at the proposed station areas. There are three main forms of commuter rail stations that can be implemented in the MAG region:

Midline Stations – Located along the central portions of the commuter rail line, these stations usually consist of a station platform, park-and-ride lot, and connections to local bus service. The ridership base for these stations is typically an area of five to 10 miles from the station.

Transit Hubs – These stations are designed to link multiple forms of high capacity transit. Park-and-ride and transit connection facilities are also provided at these stations, but to a greater extent than with the midline stations. Included within this classification is the central area terminal, which acts the main transfer point for all transit services in the region.

Terminal Stations – These stations are located at or near the end of a commuter rail line. The ridership base for these stations is typically larger than for midline stations since there may be development located beyond the terminus of the commuter rail network. Park-and-ride facilities for terminal stations are usually more substantial than those at midline stations. Some midline stations may operate as terminal stations if there are large distances between stations.

Station facilities include park-and-ride lots and connections to local bus, BRT and LRT services. Table 6-3 summarizes the station areas identified for each corridor and the proposed facilities for each station area.

Table 6-3 **Station Infrastructure and Facilities**

Station Area	Type of Station	Park and Ride	LRT Connection	BRT/ Express Bus Connection	Local Bus Connection
Burlington Northern Santa Fe					
Downtown Phoenix	Transit Hub	Regular	✓	✓	✓
West Phoenix/East Glendale	Midline	Regular		✓	✓
Downtown Glendale	Midline/ Transit Hub	Regular	✓		✓
Peoria	Midline	Regular			✓
El Mirage	Midline	Large			✓
Surprise	Terminal	Large		✓	✓
Wickenburg	Terminal	Regular			✓
Union Pacific Yuma					
Downtown Phoenix	Transit Hub	Regular	✓	✓	✓
West Phoenix	Midline	Regular			✓
Tolleson	Midline	Large		✓	✓
Goodyear/Avondale	Midline	Large			✓
Buckeye	Terminal	Large			✓
Union Pacific Southeast					
Downtown Phoenix	Transit Hub	Regular	✓	✓	✓
Sky Harbor Airport	Transit Hub	Small	✓	✓	✓
Downtown Tempe	Transit Hub	Small	✓	✓	✓
East Tempe/West Mesa	Midline	Regular	✓	✓	✓
Downtown Mesa	Midline	Regular	✓		✓
Gilbert	Terminal	Large			✓
Chandler (North)	Terminal	Large		✓	✓
Chandler (South)	Terminal	Regular			✓
Williams Gateway	Midline	Regular		✓	✓
Queen Creek	Terminal	Regular			✓

Central Terminal Area

Downtown Phoenix will be the most likely location for a central terminal commuter rail station. This placement is a result of the convergence of all three freight rail lines in downtown Phoenix and the proximity of the Central Phoenix/East Valley (CP/EV) LRT line and the bus rapid transit (BRT)/express bus service being operated by the City of Phoenix. Placement of the central terminal will be important in regards to establishing linkages between a commuter rail network and the other forms of high capacity transit operating in the downtown Phoenix area. The station could be a major transit hub linking multiple commuter rail lines together with other regional high capacity transit service.

There are several possible general locations for a central terminal in the downtown Phoenix area. Each location has strengths and drawbacks in terms of automobile access, pedestrian access, feeder bus access, linkages to other forms of transit, capital cost, and available land to accommodate a station. Table 6-4 summarizes the strengths and weaknesses of each general location.

Table 6-4 **Central Terminal Area Locations**

Station Area	Strengths	Weaknesses
State Capitol	Good street access Link to express bus network	Detached from downtown Long distance to LRT system
Union Station	Existing facility	Poor street access Long distance to LRT system Little room for expansion
Central Avenue	Good street access Good links to LRT and BRT	Land availability questionable
Ballpark/Arena	Good links to LRT and BRT Opportunity for multi-use zone	Special events may impact station access
Sky Harbor Airport	Could create true multi-modal facility Good links to LRT system Good freeway access	Detached from downtown

6.2 Commuter Rail Alternatives

Table 6-5 provides a basic evaluation of the freight rail lines capable of accommodating commuter rail operations. The rankings shown for the demographic elements and for the corridor characteristics are with respect to a comparison with all identified corridors in the Maricopa region, not only existing rail corridors.

The information presented in Table 6-5 indicates that, based on the travel market of each corridor the two UP corridors to the southeast and south (Chandler Lead) appear to have the higher priority for implementation followed by the BNSF and UP Yuma corridors.

Table 6-5 **Relative Ranking of Railway Corridors**

	Corridor			
	BNSF	**UP Yuma**	**UP Southeast**	**UP Chandler**
Trip Characteristics				
Intra Corridor Trips	High	Intermediate	High	High
Average Intra Corridor Trip Length	Long	Intermediate	Long	Long
Demographic Characteristics				
Population	High	High	High	High

	Corridor			
	BNSF	UP Yuma	UP Southeast	UP Chandler
Population Density	Moderate	Moderate	High	High
Employment	High	High	High	High
Employment Density	Moderate	Moderate	High	High
Preliminary Ranking in Terms of Corridor Characteristics	Tier 2	Tier 2	Tier 1	Tier 1
Feasibility of Implementing Commuter Rail	Requires significant investment	Moderate	Moderate	Moderate

6.3 Commuter Rail Equipment

There are primarily two types of equipment in service in North America: electric multiple unit (EMU) train technology on older East Coast systems and on most other systems, diesel powered, locomotive-hauled trains.

Electric propulsion is comparatively quiet and emission-free, but there may be environmental impacts depending upon the technology used to generate the electricity. A very large investment in infrastructure is required to provide the source of power. However, multiple unit technology has two main advantages when compared to locomotive-hauled trains:

- The flexibility to tailor train length to demand during different times of the day and to alter train length quickly;
- The ability to run "short" trains during off-peak hours at reduced operating costs.

A new alternative to the EMU is the diesel multiple unit (DMU) technology, using self-propelled diesel powered vehicles eliminating electrical infrastructure cost, while retaining of the system flexibility and lower operating costs. This technology would be an appropriate type of equipment for a new start commuter rail operation in the MAG region if the safety constraints of these vehicles can be overcome. The Federal Railroad Administration (FRA) sets standards for railway equipment that is used in areas with mixed rail traffic, and does not permit existing European DMU designs to be imported directly into North America. The Colorado Rail Car company has a design that is said to meet FRA requirements, but is not yet in commercial service. In the future, it is expected that suitable diesel multiple unit vehicles should be available, providing the advantages of multiple unit equipment with more modern design, including low floor cars which speed boarding and alighting and superior acceleration and deceleration rates providing faster travel times.

Despite the advantages of the DMU technology, the constraints described above have resulted in all new start commuter rail systems in North America being equipped with an almost uniform configuration of a diesel locomotive-hauled train of double deck cars. Commuter rail services in this configuration are operated in push-pull mode, with a locomotive at one end and a cab car at the other end; these trains can reverse without any changes to the train makeup. For the purposes of testing, the characteristics of such push-pull, diesel locomotive-hauled systems will be used. These characteristics include capacity and acceleration/deceleration rates. As implemented in most new start systems, bi-level equipment trains can be up to 10 cars in length, with a passenger capacity of up approximately 160 seats per car with additional standing capacity.

Bi-level cars offer an advantage over single-level cars in passengers per unit of train length and per unit of operating and capital costs. These vehicles are also suitable for locations where station platform length may be limited. These vehicles are available in a variety of configurations, and with procurement costs which favorably reflect the large order numbers. The recent trends in specifications have been for higher levels of on-board amenities, reflecting not just funding but the need to provide competitive comfort levels to the auto.

Commuter rail services can be supplemented with buses in the off-peak time period and off-peak direction, particularly in the Phase 1 period, providing additional flexibility for users.

6.4 Fare Systems

Virtually all new North American urban rail systems have implemented a Proof-of-Payment (POP) fare payment system given the operational and cost efficiencies. A POP system is a barrier-free (no turnstile) self-service fare collection system where ticket inspectors check passengers for proof-of-payment in the form of a validated ticket, pass or bus transfer, purchased from ticket vending located at stations. Ticket inspectors also serve a role as information officers who can assist passengers, and contribute to perceived and actual passenger safety. Fare evasion rates typically range from one to three percent in North American applications - lower than with conventional bus fare boxes and turnstile systems.

Older commuter rail systems use more labor-intensive on-board fare collection, with sales and ticket collection are carried out by crew members, and zone or seat checks.

Ticket vending machines (TVM) are very common with commuter rail systems and provide operational and convenience benefits regardless of the fare collection system used. Given the highly peaked nature of customer arrivals to commuter rail stations, TVM's are used to supplement sales staff during these peaks, and can provide a wide range of functionality with more advanced machines capable of accommodating all ticket media/passes a full range of payment options and parking validation.

Fare policies for a commuter rail system are typically more sophisticated than conventional public transit system, typically distance or zone-based. Other considerations for a MAG region commuter rail system include peak and off-peak fares, bus transfer credit/discounts and for regular commuters, discounts for weekly, monthly and even yearly tickets. Multi-ride non-time expiration tickets also offer incentives for frequent travelers with varied origin and destination needs.

Electronic fare collection is a developing trend among transit agencies, with fare integration between multiple transit operators often a driving force. Such systems include technologies to improve convenience to the transit user, introduce and equitable fare structures, reduce fraud, and improve financial and service management information. Contactless smart card technology is becoming established and is in the process of being implemented in several major transit properties in the Western U.S., including the San Francisco Bay Area and Puget Sound (Seattle).

Table 6-6 provides an overview of the fare collection methods for selected North American commuter rail operations.

Table 6-6 **Fare Systems Used By North American Commuter Rail Systems**

Commuter Rail System	Urban Area	Ticket Collection/Inspection	TVM	Fare Structure
Long Island Railroad (LIRR)	New York	On-board*	Yes	Zone Based
Metro-North Railroad	New York	On-board*	Yes	Zone Based
New Jersey Transit Corporation (NJ Transit)	New York/New Jersey	On-board*	Yes	Zone Based
Regional Transportation Authority (Metra)	Chicago	On-board and fare gates (one line)	No	Zone Based
Northern Indiana Commuter Transportation District (NICTD)	Chicago	On-board*, fare gates in Chicago	No	Zone Based
Massachusetts Bay Transportation Authority (MBTA)	Boston	On-board*, planning to go to POP	No	Zone Based
Southeastern Pennsylvania Transportation Authority (SEPTA)	Philadelphia	On-board*	Yes	Zone Based
Peninsula Corridor Joint Powers Board (CalTrain)	San Francisco	On-board*, planning to go to POP	Yes	Zone Based
Mass Transit Administration, Maryland DOT (MARC)	Baltimore	On-board*	No	Zone Based
Tri-County Commuter Rail Authority	Miami	POP	Yes	Zone Based
Virginia Railway Express	Washington D.C.	POP	Yes	Zone Based
Southern California Regional Rail Authority (Metrolink)	Los Angeles	POP	Yes	Zone Based
North County Transit District (Coaster)	San Diego	POP	Yes	Zone Based
Sounder	Seattle	POP	Yes	Zone Based
Altamont Commuter Express	San Jose	POP	No	Zone Based

Commuter Rail System	Urban Area	Ticket Collection/Inspection	TVM	Fare Structure
Trinity Railway Express	Dallas-Fort Worth	POP	Yes	Zone Based
Canadian Systems				
Go Transit	Toronto	POP	No	Distance Based
Agence Metropolitaine de Transport	Montreal	POP	Yes	Zone Based
West Coast Express	Vancouver	POP	Yes	Zone Based

* A $2-$3 surcharge applies if tickets are purchased on-board and ticket office is open.

6.5 Feeder Networks

"Feeder" bus service typically refers to special bus routes whose sole purpose is to connect a high capacity transit corridor to a major origin or destination area off the line. Whether high capacity transit is implemented as commuter rail services, BRT or light rail, the stops would be "stations" for transfer activity, parking, or pedestrian connections to the nearby activity centers. One-quarter mile is a reasonable distance for most people to walk to transit. For frequent or scheduled high capacity transit services, up to ½ mile may be reasonable, although summer heat in the Phoenix area can dissuade persons from walking long distances, encouraging the use of feeder/collector services.

Types of High Capacity Transit Feeder Bus Connections

A high capacity transit line can make useful connections with any of several types of bus service:

- **Regular local high-frequency service** - Local bus services operating along the most heavily traveled local corridors are important because they allow riders to make complete trips using the most time-efficient elements of a transit system. Regular bus service is appropriate for corridors with intensive linear development, as well as major end-of-corridor destinations.

- **Regular local low-frequency service timed to a high capacity transit line with a regular schedule pattern** - Low-frequency local service requires passengers to plan trips around the bus schedule. If local service runs at frequencies of 30 minutes or worse, then it becomes much less useful as a high capacity transit connection tool, and dedicated feeders are more likely to be needed. If the frequencies of local bus service and the high capacity transit service are coordinated, then the effectiveness of this feeder service is dramatically increased.

- **Dedicated fixed-route feeder service timed to meet high capacity transit vehicles** - Dedicated shuttles, especially those operating at peak-hours, can perform well if their sole purpose is to connect a major transit center to a large worksite, especially if they connect with rail services. Ideal markets for dedicated fixed-route feeders include high-rise employment centers in suburban areas, where a large number of people can be served at a single stop (work-end shuttles). Dedicated feeders can often be run with small vehicles that can pull up to the door of buildings with large setbacks.

- **Dedicated flex-route feeder service timed to meet high capacity transit vehicles** - Flex-route feeders using small vehicles timed to meet specific high capacity transit trips can be an excellent tool for several challenging transit markets including low-density business park environments, rural areas, and areas where concentrations of development are separated by large rural gaps or unused desert lands. Trips can be requested in advance over the phone or the web for both inbound and outbound trips.

Table 6-7 shows which kinds of service tend to fit with different types of high capacity transit.

Table 6-7 **Compatibility Between High Capacity Transit and Feeder Service**

Frequency →	30 Min or Longer	15 Min or Less
Connecting Service Type		
Regular local fixed routes, 15 min or better	Fair	Good
Regular local fixed routes, 30 min or longer	Poor	Fair
Timed, dedicated fixed route feeders	Best	Good

Feeder Requirements for Different Levels of Investment

This report describes three different infrastructure levels of service for commuter rail. Feeder requirements will differ significantly depending on the different levels of infrastructure investment. For example, under the Phase 1 commuter rail service — where three peak runs would be provided each day — dedicated shuttles and fixed route feeders are required. These should be specifically timed to serve the arrivals and departures of the high capacity transit services. It may be appropriate to develop special services that supplement the existing transit network. For example, it would be unnecessary to run buses to a station all day unless the station serves the dual purpose as a transfer hub for bus connections. Likewise, maintaining a current hourly schedule when the peak trains are operating every 30 minutes or (90 minutes) would reduce the effectiveness of the feeder system.

At the Phase 3 level of commuter rail service (peak service every 15 minutes and off-peak service every 30 minutes), a productive network of feeder services should provide for high-frequency local bus service, as well as dedicated employer shuttles designed to meet each train. If bus services are frequent enough, during the peak (every 15 minutes), it may not be necessary to schedule them around the train schedule because the longest wait between any train and bus would be 15 minutes, with the majority waiting less; at this high level of commuter rail service, it is useful to simplify the routing of major corridors where very high-frequency feeder service is provided.

Determining Demand for New Feeder Services

Even though the majority of feeder networks are expected to be provided by the existing transit network, there will be corridors where new feeder services may be warranted. While there are no quantitative criteria for determining when a feeder service is desirable or has a high likelihood for success, there are several qualitative criteria that are appropriate to consider when planning for feeder services:

- Proximity to employment sites and limited or no existing transit service
- Capacity constraints as defined by parking availability and affordability
- Direct transit service connections to nearby activity centers
- Community support
- Private sector funding

As with any new service, it is important to evaluate whether it is successful. The key question is, "What defines success?" While there are many factors that contribute to the success of a service, there are a small number of performance measures that are standard in the transit industry. For a feeder network, performance expectations address passenger productivity, cost effectiveness and the level of financial support.

7.0 Alternative High Capacity Transit Services

In addition to commuter rail services, other types of high capacity transit services are also being considered for implementation in the MAG region. These alternative high capacity transit services include light rail transit (LRT) and bus rapid transit (BRT). These two transit services have the capability to serve a different market than commuter rail. Specifically, these services are flexible enough to be tailored to directly serve employment centers, where as commuter rail is fixed to a specified corridor.

The LRT and BRT services are both extremely flexible types of transit, which could be implemented in a variety of corridors including existing freight rail corridors. LRT or BRT service could be implemented in place of commuter rail if it is determined that commuter rail is not feasible on a specific rail corridor, or these transit services could be implemented in conjunction with commuter rail to serve a separate market of shorter transit trips.

Corridors that present alternative alignments for LRT and BRT services include arterial streets, freeways, and non-traditional transportation corridors such as utility easements and flood control channels. Both LRT and BRT are capable of being implemented in either elevated or at-grade configurations. Additional options for minimizing traffic impacts and improving system operating speeds are also available in form of reserved rights-of-way or exclusive travel lanes.

7.1 Transit Networks

Two networks of proposed transit enhancements have been developed using the travel corridors identified during Milestone 2. Each of these networks was developed using a set of base transit alternatives, which included both a radial and grid orientation to providing service. Potential commuter rail, LRT, and BRT services are included within each network. Three base alternatives were developed and then combined to form two networks of transit improvements illustrated in Exhibits 7-1 and 7-2. As illustrated in the exhibits, several types of transit technologies were identified in the two networks. Commuter rail is proposed along several freight rail corridors in the MAG region. More extensive BRT express bus services are proposed to operate on the freeway network. These services can operate in a similar fashion to the existing express bus service operating in the region, serving park-and-ride lots located near the freeway system. As alternative, online stations could be constructed for these services so that the express bus service does not need to exit the freeway. Both LRT and BRT services have been proposed for arterial street, freight railroad, and flood control corridors. These technologies have been identified in tandem due to their operating similarities. Specific selection of a single technology would occur as capital and operating costs are developed and travel demand within the corridor is identified. Using this data, the most appropriate single technology could then be selected for the corridor. Summaries of the base alternatives and the two transit networks are provided below:

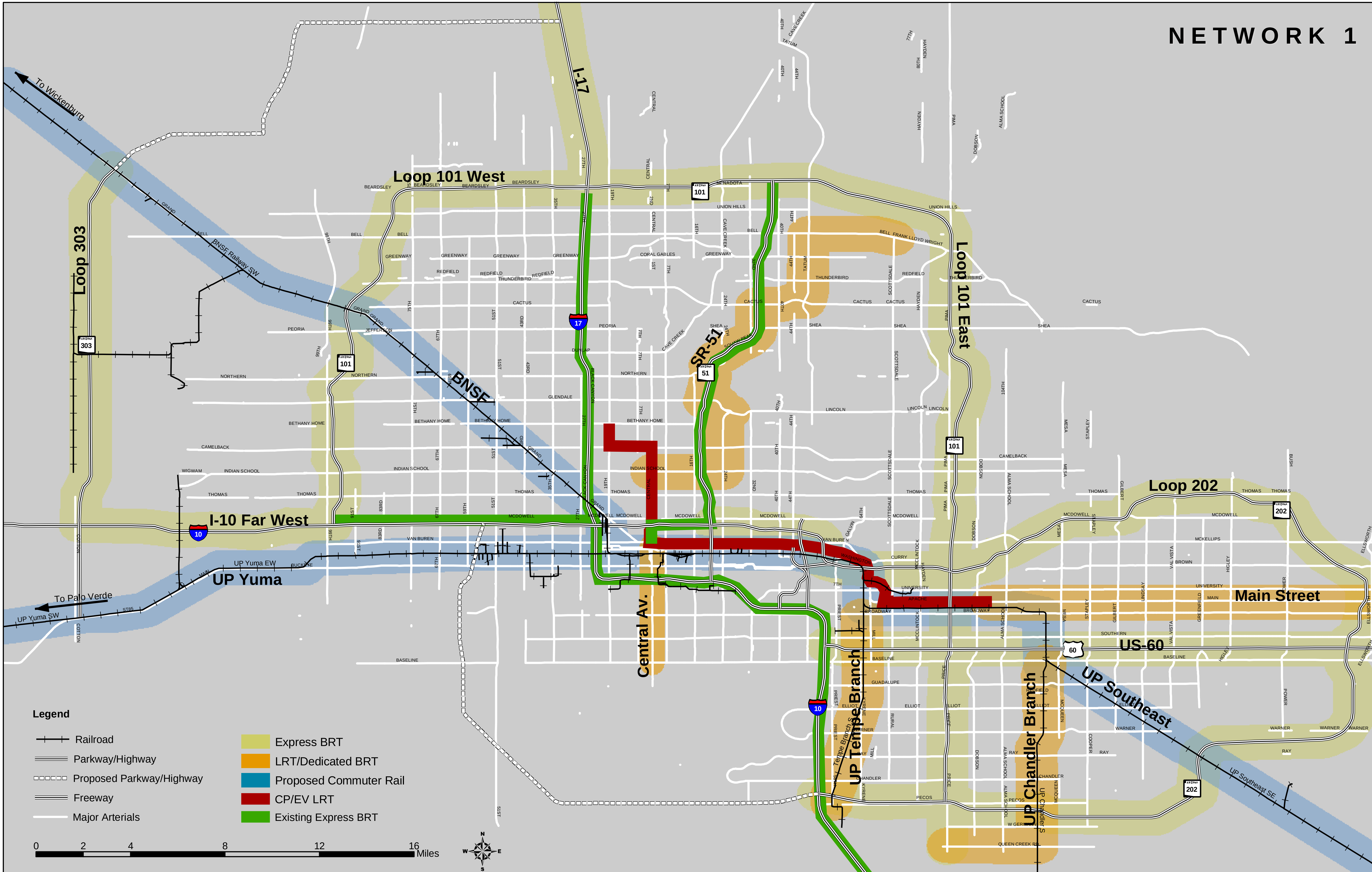
Base Alternative A – This alternative is built around long distance express bus service operated on the regional freeway system combined with commuter rail on freight corridors. The proposed express bus network for the City of Phoenix has been used as a base for this alternative. This alternative would serve long distance trips to and from major employment and activity centers with a radial pattern of alignments. Park-and-ride lots would be an integral part of this alternative since each corridor will draw riders from a large area.

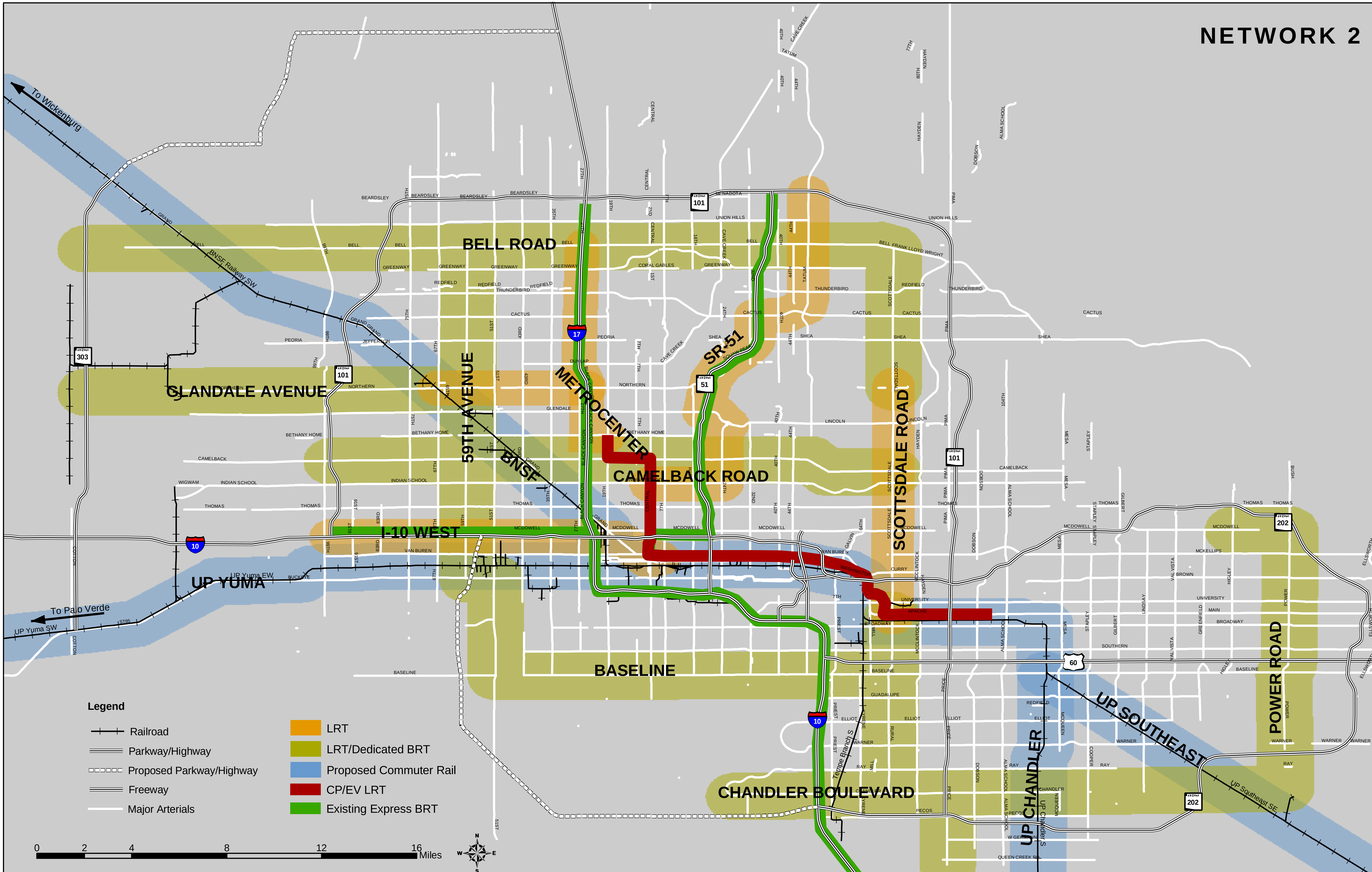
Base Alternative B – Alternative B is built around LRT and BRT service in a radial pattern serving major employment centers located throughout the MAG region. This alternative was designed to serve more short distance trips than Alternative A, primarily using LRT and BRT technologies. The alignments in this alternative could take advantage of several different corridors including streets, freight railways, and utility easements or flood control channels. The Central Phoenix/East Valley LRT system was used as the central link for these radial corridors, which are focused on serving major employment centers throughout the MAG region.

Base Alternative C – The grid street system in the MAG region serves as a baseline guide for this alternative. LRT and BRT services are configured in north-south and east-west alignments to create a full coverage high capacity transit system across the MAG region. As is the case with Alternative B, these corridors serve primarily shorter distance trips. This alternative was designed to also use the CP/EV LRT as a base.

Network 1 – This network is a combination of Alternatives A and B, serving both long and short distance trips with a series of radial alignments focused on major activity and employment centers located throughout the MAG region.

Network 2 – A combination of Alternatives A and C comprise this network, designed to serve long and short distance trips with long distance radial corridors linked to the grid system of LRT and BRT service. Major activity and employment centers can be accessed through both the radial and grid corridors.


NETWORK 1
I-17
Loop 101 West
Loop 303
To Wickenburg
BNSF Railway SW
BNSF
I-10 Far West
UP Yuma
UP Yuma EW
UP Yuma SW
To Palo Verde
SR-51
Central Av.
Loop 101 East
Loop 202
Main Street
US-60
UP Southeast
UP Southeast SE
UP Tempe Branch
UP Chandler Branch
Legend
Railroad
Parkway/Highway
Proposed Parkway/Highway
Freeway
Major Arterials
Express BRT
LRT/Dedicated BRT
Proposed Commuter Rail
CP/EV LRT
Existing Express BRT
0 2 4 8 12 16 Miles
April 14, 2003


NETWORK 2
BELL ROAD
GLANDALE AVENUE
59TH AVENUE
BNSF
METROCENTER
CAMELBACK ROAD
SR-51
SCOTTSDALE ROAD
I-10 WEST
UP YUMA
BASELINE
CHANDLER BOULEVARD
UP CHANDLER
UP SOUTHEAST
POWER ROAD
To Wickenburg
To Palo Verde
BNSF Railway SW
UP Yuma SW
UP Yuma EW
UP Southeast SE
Legend
Railroad
Parkway/Highway
Proposed Parkway/Highway
Freeway
Major Arterials
LRT
LRT/Dedicated BRT
Proposed Commuter Rail
CP/EV LRT
Existing Express BRT
0
2
4
8
12
16
Miles
April 14, 2003

7.2 Levels of Service

As with the commuter rail corridors, it is suggested that a full-length network of BRT and LRT services would not be implemented in a single step, but rather developed incrementally, with capital infrastructure reflecting expected demand. The ability to increase level of service incrementally with relatively low marginal costs is particularly an advantage of BRT. Unlike commuter rail, the transition from the initial network to the final network can be developed gradually, rather than through large discrete improvements.

The BRT and LRT corridors would operate together as a network, with interchange stations operating as strategic elements in the system. In order for the interchange opportunities at these locations to be properly utilized, frequencies on the BRT and LRT services need to be as high as can be justified by demand. These corridors have been selected as potentially able to support at least a reasonable service and initial intervals should be no greater than 20 minutes; more infrequent than this and strategic use of the transit network becomes unattractive. Peak periods would have higher frequencies, and eventually it is hoped headways could be reduced to five minutes or less on the major transit routes.

An important determination made during the development of the BRT and LRT corridors is the identification of which technology is better suited for implementation in a particular corridor. Both LRT and BRT are extremely flexible transit services capable of operating in a variety of corridors and in a variety of configurations.

LRT systems have the ability to influence land use and surrounding population density. The presence of an LRT station can create opportunities for mixed-use development and higher densities as commuters seek to live and work near the stations. These land use changes can result in a greater number of people relying on transit and pedestrian travel for trips, reducing the overall amount of vehicular congestion in the vicinity of stations. A BRT system is also capable of influencing land use development if the operating characteristics and station spacing are similar those of an LRT system.

The ability of buses to operate without a fixed guideway allows BRT the additional flexibility to modify and extend routes much more quickly and cost-effectively than an LRT system. BRT systems have the ability to operate in corridors with lower population densities than LRT. The lower capital investment costs for BRT also make technology more cost effective in lower density areas. One disadvantage of BRT is that the alignments are typically located at-grade, potentially resulting in a greater level of traffic impacts when compared to an elevated LRT system. In some cases, BRT vehicles can be separated from other forms of traffic by either a raised curb or an exclusive striped lane to minimize the impacts of the service on vehicular traffic. Typically, more separation for BRT vehicles from other forms of traffic will result in greater operating speeds and reduced traffic impacts.

In all likelihood, LRT systems would be the preferred technology in high density, heavily congested corridors. Grade separation of the LRT system should also be considered in order to reduce traffic impacts and increase the effectiveness of the system. BRT systems would be more appropriate for lower density areas with less traffic congestion were the cost-effectiveness of BRT would be more apparent.

An additional concept that will be explored is a possible transition from BRT to LRT. The BRT phase would include the acquisition of rights-of-way and construction of roadway structures. As population densities and ridership increase in the corridor, the transit system can be upgraded to an LRT corridor more cost-effectively than what would have been the case originally. Almost all of the BRT infrastructure can be used for an LRT system if it is decided to upgrade to such a system. Thus, a BRT system can be seen as a stage in the path to implement an LRT system.

Additional discussion about the strengths of each technology is presented later in this report.

Screening and Evaluation

This study up this point has primarily been concerned with the consideration of alternatives – corridors, networks, technologies. At this stage, the focus of the report was shifted to an evaluation of alternatives, subsequently forming the basis for the MAG Recommended High Capacity Transit Network.

Table 7-1 below sets out the criteria envisaged for inclusion in this process. These include the major criteria used in recent major investment studies for investment in transit corridors including BRT.

Table 7-1 Proposed Evaluation Criteria

SCREENING AND EVALUATION	DRAFT EVALUATION CRITERIA	Key Indicator:	First Level Screening	Second Level Screening
Transportation Demand	**Population & Employment**	population density x per acre	▶	
	Employment	employment density x per acre	▶	
	Activity Centers	key employment, retail, public facility connectivity		
	Transit Dependent Population	age and income level per acre/TAZ overall	▶	
	Equity/Env. Justice	employment accessible by income quintile X	▶	
	Equity/Env. Justice	employment accessible by ethnic groups	▶	
Land Use Plans & Policies	**General Plans, Community Plans**	overall Plan, zoning consistency	▶	
	Redevelopment Project Areas	'blight' reduction / links redevelopment areas		▶
Traffic Conditions	**Existing Infrastructure (ROW)**	readiness/condition	▶	
	Existing Traffic Levels of Service	LoS E or worse in peak commute	▶	
	Future Traffic Forecasts	growth rel to reg ave on arterials, LoS deterioration	▶	
Travel Patterns; Existing and Projected	**Origin-Destination Patterns**	TAZ O-D analysis match	▶	
	Mode Choice	maximize transit retention/minimize leakage to drive alone		▶
	journey time reduction	quantified as % of current transit trip time, selected O-D pairs	▶	
Transit Service & Ridership Patterns	**Existing Routes**	complementary or competitive		▶
	Line-by-Line Ridership	impact on on r'ship		▶
	User Amenities	qualitative enhancement		▶
Cost and Cost Effectiveness	**Cost per person**	within corridor from available MAG data		▶
	Per Rider Cost	per rider by mode/corridor		▶
Regional Context	**MAG Long Range Plans**	consistency with LRP	▶	
Urban Design Considerations	**Corridor Enhancement Potential**	sidewalks, ped environment/safety, landsace enhancement potential		▶
	Distinct Neighborhood Characteristics	secure and reinforce n'hood identity		▶
	Station Area Cohesion	ToD development potential		
Community Input	**Elected Officials Input**	from public involvement plan	▶	▶
	Public Input	from public involvement plan	▶	▶
STUDY OVERALL	**Improve Mobility**	overview	▶	▶
	Support Land Use and Development	overview	▶	▶
	Respond to Community Input	overview		▶
	Enhance the Physical Environment	overview		▶
	Minimize Impacts	overview	▶	▶
	Implement Cost-Effective Project	overview	▶	▶

8.0 Ridership and Cost Estimates

Cost and ridership estimates are provided for potential commuter rail, light rail, and bus rapid transit high capacity transit corridors in the MAG region. These corridors, including the corridor limits and proposed transit technology are summarized below. Each alignment identified in this section represents a single centerline street or freeway selected for ridership and cost estimates. The actual corridors are approximately five miles in width and a final alignment could include other streets parallel to the alignments identified in the table.

Two sets of ridership and cost estimates were prepared during the course of the study for the proposed high capacity transit corridors. The preliminary set of estimates developed in Milestone 4 utilized the population and employment forecasts available at the time. After analyzing the initial results and with the adoption of the MAG Draft 2 population and employment forecasts, a refinement of ridership and cost estimates was undertaken so that the results would more accurately reflected projected socioeconomic growth in the MAG region. The ridership and cost estimates contained in this report reflect the refined MAG Draft 2 population and employment forecasts used in the Milestone 5 report.

8.1 Commuter Rail Ridership

Ridership and cost estimates have been developed on four potential commuter rail corridors. The corridors and limits assumed in the ridership and cost estimates are summarized in Table 8-1.

Table 8-1 **Potential Commuter Rail Corridors**

Corridor	Limits
Burlington Northern Santa Fe (BNSF)	Downtown Phoenix to Loop 303 *(potential extension to Wickenburg)*
Union Pacific Mainline/Chandler	Downtown Phoenix to Queen Creek Road
Union Pacific Southeast	Downtown Phoenix to Ellsworth Avenue
Union Pacific Yuma	Downtown Phoenix to Buckeye *(potential extension to Palo Verde Nuclear Generating Station)*

Commuter rail ridership was forecast using a direct demand model (DDM). The more traditional four stage modeling approach was considered less suitable at this stage due to the absence of commuter rail as a mode in the MAG model, and its much slower application than the quick sketch planning forecasts that the DDM can produce. This DDM estimates weekday boarding passengers per station based on the catchment population and level of service factors such as train frequency and journey time savings.

Catchment areas were developed for each proposed station to represent the major source of all trip origins. Catchments were developed with three mile radii for the primary catchment area and an additional two to four miles for the secondary catchment area, resulting in a catchment area with a five to seven mile radius overall. Manual adjustments were made to reflect observed catchment shape characteristics and to ensure no overlaps between station catchments. Catchments of alternative locations for the same station could overlap. Catchment population was determined and this was applied to a trip rate to determine the total number of weekday trip boardings at each station. Stations designated as 'destination' stations were not included as they would primarily represent trip attractions rather than trip productions.

The trip rate factors were originally calibrated from the GO Rail system in Toronto with subsequent adjustments, and include factors to allow for:

- Number of peak period trains;
- Presence/absence of an off-peak service; and
- Time/distance factors.

Weekday corridor ridership was determined by summing all the respective stations. Where more than one option for a station location existed, the location producing the most boardings was selected. Since daily ridership also includes the return leg of the daily round trip the sum of station boardings were also doubled.

Ridership was estimated using the service plan implementation process developed in Milestone 3. As noted previously in Section 6, three phases of commuter rail implementation were assumed in the study:

- Phase 1: Start-Up/Introductory Service. Limited peak hour, peak direction service composed of three trains inbound in the a.m. peak and outbound in the p.m. peak on each of the networks.
- Phase 2: Intermediate Service. Headways of 20 minutes during the peak hour will be examined together with limited counter-flow service. Midday service would consist of hourly trains in each direction.
- Phase 3: Full Commuter Train Operation. In this phase, trains would operate on 15-minute headways during the peak hours and at 30-minute headways during the off-peak. During the peak periods there would be a 30-minute interval counter-flow services.

Based upon the results of the capital cost estimates and discussions with representatives from BSNF and UP, it was determined that only the Phase 1 and Phase 3 levels of service would be carried forward for full evaluation. Phase 1 service represents the minimum amount of service that needs to be provided to operate a potentially viable commuter rail service, with three trains operating during the peak commute. Phase 3 service would be the ultimate operation of commuter rail service which would provide residents of the MAG region with a true "turn up and go" service providing frequent and reliable service throughout the day during both peak and off-peak commute times. Phase 2 (Intermediate Service) is not being specifically evaluated. Instead, this service will be addressed qualitatively during the discussion of phasing and implementation later in this report.

Several of the data input assumptions for commuter rail service have been adjusted for Milestone 5 in light of the revised population projections and input from the Agency Working Group. Table 8-2 summarizes the refinements made to the commuter rail assumptions during the course of the study.

Table 8-2 **Refined Commuter Rail Assumptions**

Data Input	MS 4 Assumption	MS 5 Revised Assumptions
Population Projection (2040)	Adopted population projections for the MAG region with a 2040 build out population of 6.4 million residents.	Updated population projections for the MAG region with a 2040 (Draft 2 Socioeconomic projections) build out population of 7.4 million residents. Phase 1 ridership estimates based upon 2020 Draft 2 population projections.
Stations	BNSF 6 stations.	BNSF 7 stations (additional Surprise station at Loop 303). All other corridors the same.
Station Catchment Area	3-mile primary catchment (secondary catchment to 5 miles).	3 miles primary, out to 10 miles for secondary catchment.
Costs	No change, however revisions were made between MS 4 drafts to refine some unit costs and the number of vehicles required.	Same as revised MS 4 but with more vehicles and parking spaces. Additional refinements to unit costs were also made.
Commute	No reverse commute.	Reverse commute assumed on all corridors.

Commuter rail ridership estimates were developed in a two stage process as the assumptions for ridership generators were refined through discussions with the Agency Working Group and MAG staff. Initial forecasts were based upon the previous population projections. These forecasts were revised once the MAG Draft 2 population and employment forecasts were released. In addition to the revised socioeconomic data, refinements to the ridership forecasts included reverse commute service away from central Phoenix, additional stations on the BNSF corridor to serve population growth in the northwest, and an expansion to the station catchment areas to account for low density development in the MAG region.

Table 8-3 below summarizes the total weekday commuter rail ridership in each corridor. An important distinct is the use of 2020 ridership forecasts for the Phase 1 level of service. For all other ridership forecasts for commuter rail and other technologies (LRT and BRT), the Year 2040 was assumed as the forecast horizon year. However, Phase 1 commuter rail service presents a special case, because service in this stage will likely have a forecast horizon year of 2020. The Phase 1 ridership figures presented below are designed to provide a more accurate view of forecasted ridership in a future year that corresponds well to a probable opening time period for commuter rail service. This table also summarizes the change on forecasted ridership from each corridor resulting from the refinements noted above.

Table 8-3 **Commuter Rail Total Ridership Forecasts**

Corridor	Total Boardings		Percent Change from Milestone 4	
	Initial (Phase 1) 2020	Ultimate (Phase 3) 2040	Initial (Phase 1) 2040	Ultimate (Phase 3) 2040
BNSF	4,862	16,145	70%	101%
UP Chandler/Mainline	1,372	4,561	15%	36%
UP Southeast	1,970	6,198	-19%	-5%
UP Yuma	2,710	12,034	17%	85%

Note: The boarding figures contained within this table have been obtained from a sketch planning model.

The action of adjusting Phase 1 ridership estimates to the Year 2020 has an effect upon cost estimates for Phase 1 service by lowering the expected initial costs for vehicles and station parking facilities. These refined ridership figures have no effect upon the cost of implementing and operating the Ultimate (Phase 3) level of service. Instead, the influence of this distinction is focused on the estimated *initial* cost of implementing commuter rail service. This distinction was made to present a more accurate forecast of ridership and costs for Phase 1 Start-up commuter rail service.

8.2 Commuter Rail Capital and Operating Costs

Two factors were used as a basis for developing capital and operating costs for commuter rail service in the four freight railroad corridors. The ridership forecasts contained in Table 8-3 above were used to estimates requirements for rail vehicles and station facilities. The rail infrastructure requirements outlined in Section 6 served as the base for determining the cost of new infrastructure.

Commuter Rail Capital Costs

Capital costs were developed using standard unit cost rates obtained from the Southern California Regional Rail Authority (Metrolink), and unit costs obtained from several other rail infrastructure cost estimates prepared for West Coast rail properties during the previous five years.

A major component of the cost of new start commuter rail systems is track ownership or the lease rights to use freight rail corridors. The purchase or lease of rights to utilize the MAG region freight railroad corridors varies between each phase and each corridor. Phase 1 services assume the lease of track rights from the freight railroad services, with trains providing service during operating windows provided by the freight railroad companies, Burlington Northern Santa Fe (BNSF) and Union Pacific (UP). These lease rates are an estimate based upon the number of annual train miles and are incorporated into the annual operating and maintenance costs. The rates represent an average cost paid by other West Coast commuter rail systems operating in freight corridors owned by BNSF and UP. In corridors where second main tracks are constructed, right-of-way purchase is assumed in the capital cost for Phase 2 and 3 services where increased frequency of service would likely preclude the use of operating windows between freight services. Due to the limited amount of freight operations occurring in the corridor, the Union Pacific Yuma corridor does not require a second main track, allowing for the lease of track rights through all three phases of service implementation.

Table 8-4 compares the capital costs presented in Milestone 4 and revised capital costs for each corridor. The costs for the Startup and Full Service phases are both included in this table. Additional detail for the commuter rail capital costs is provided in Table 8-5. All costs are in Year 2001 dollars.

Table 8-4

Commuter Rail Capital Cost Comparison

Commuter Rail Corridor	Preliminary Capital Costs ($ millions)	Revised Capital Costs ($ millions)	Change in Capital Cost (MS 4 to MS 5)
BNSF Phase 1	$289.39	$292.30	$2.91
BNSF Phase 3	$360.40	$445.63	$85.23
BNSF Total	$649.79	$737.93	$88.14
UP Mainline/Chandler Phase 1	$273.87	$269.93	-$3.94
UP Mainline/Chandler Phase 3	$265.41	$260.29	-$5.12
UP Mainline/Chandler Total	$539.29	$530.22	-$9.07
UP Southeast Phase 1	$295.88	$270.34	-$25.54
UP Southeast Phase 3	$348.66	$297.15	-$51.51
UP Southeast Total	$644.54	$567.50	-$77.04
UP Yuma Phase 1	$141.58	$143.25	$1.67
UP Yuma Phase 3	$268.10	$308.55	$40.45
UP Yuma Total	$409.68	$451.80	$42.12

Note: Phase 3 costs under Milestone 4 represent the costs of implementing both Phase 2 (Intermediate) and Phase 3 (Full Service) commuter rail operations. All costs are in Year 2001 dollars.

Table 8-5 Commuter Rail Capital Cost Summary

Item			BNSF Phase 1	BNSF Phase 3	UP Mainline/ Chandler Phase 1	UP Mainline/ Chandler Phase 3	UP Southeast Phase 1	UP Southeast Phase 3	UP Yuma Phase 1	UP Yuma Phase 3
Corridor Length (miles)			26.18	26.18	27.95	27.95	36.18	36.18	30.90	30.90
Subtotal-Civil			$12,072,304	$198,400	$23,106,160	$188,890	$24,829,520	$334,500	$1,250,000	$1,914,000
Subtotal-Utilities			$23,138,016	$3,273,600	$13,024,440	$3,116,685	$13,024,440	$903,150	$0	$1,742,400
Subtotal-Track			$33,332,994	$6,658,195	$28,200,799	$4,666,366	$19,695,628	$7,511,088	$0	$2,460,880
Subtotal-Stations			$30,382,000	$15,414,000	$31,280,000	$3,570,000	$31,518,000	$5,124,000	$24,066,000	$11,760,000
Subtotal-Controls & Signals			$0	$28,269,856	$15,785,584	$10,908,972	$15,585,584	$18,905,720	$0	$28,454,896
Subtotal Facilities			$2,620,000	$22,000,000	$2,800,000	$15,000,000	$3,620,000	$17,000,000	$3,090,000	$20,000,000
A. Construction Subtotal			**$101,545,314**	**$75,814,051**	**$114,196,983**	**$37,450,913**	**$108,273,172**	**$49,778,458**	**$28,406,000**	**$66,332,176**
Environmental Mitigation	Percent of A	2%	$2,030,906	$1,516,281	$2,283,940	$749,018	$2,165,463	$995,569	$568,120	$1,326,644
B. Construction Cost Subtotal			**$103,576,220**	**$77,330,332**	**$116,480,923**	**$38,199,931**	**$110,438,635**	**$50,774,027**	**$28,974,120**	**$67,658,820**
C. Right of Way Subtotal			**$10,802,875**	**$128,424,550**	**$6,969,600**	**$66,536,800**	**$7,715,325**	**$73,539,500**	**$10,637,350**	**$58,318,125**
D. Vehicles Subtotal			**$76,945,000**	**$85,450,000**	**$46,587,500**	**$70,050,000**	**$54,167,500**	**$73,305,019**	**$60,525,000**	**$78,600,000**
Cost Contingencies (Uncertainties, Changes)										
Design&Construction	Percent of B	25%	$25,894,055	$19,332,583	$29,120,231	$9,549,983	$27,609,659	$12,693,507	$7,243,530	$16,914,705
Right of Way	Percent of C	30%	$3,240,863	$38,527,365	$2,090,880	$19,961,040	$2,314,598	$22,061,850	$3,191,205	$17,495,438
Vehicle Cost	Percent of D	10%	$7,694,500	$8,545,000	$4,658,750	$7,005,000	$5,416,750	$7,330,502	$6,052,500	$7,860,000
Program Implementation (Agency Costs and Fees)										
Design&Construction	Percent of B	31%	$32,108,628	$23,972,403	$36,109,086	$11,841,979	$34,235,977	$15,739,948	$8,981,977	$20,974,234
Right of Way Purchase	Percent of C	15%	$1,620,431	$19,263,683	$1,045,440	$9,980,520	$1,157,299	$11,030,925	$1,595,603	$8,747,719
Vehicle Procurement	Percent of D	5%	$3,847,250	$4,272,500	$2,329,375	$3,502,500	$2,708,375	$3,665,251	$3,026,250	$3,930,000
E. Capital Cost Subtotal			**$265,729,823**	**$405,118,415**	**$245,391,784**	**$236,627,752**	**$245,764,118**	**$270,140,528**	**$130,227,535**	**$280,499,040**
Project Reserve	Percent of E	10%	$26,572,982	$40,511,842	$24,539,178	$23,662,775	$24,576,412	$27,014,053	$13,022,753	$28,049,904
F. Total Capital Cost			**$292,302,805**	**$445,630,257**	**$269,930,963**	**$260,290,528**	**$270,340,529**	**$297,154,581**	**$143,250,288**	**$308,548,944**
			Total all 3 Phases	**$737,933,062**	**Total all 3 Phases**	**$530,221,490**	**Total all 3 Phases**	**$567,495,110**	**Total all 3 Phases**	**$451,799,232**

Note: All costs are in 2001 dollars. More detailed information on costs can be found in Appendix A.

Commuter Rail Operating Costs

Commuter Rail operating costs have been estimated using the comparison of Year 2001 bus and commuter rail operating and maintenance costs from three commuter rail service providers in the Western United States:

- Dallas Area Rapid Transit Authority (DART) – Dallas Trinity Railway Express
- North County Transit District (NCTD) – San Diego Coaster
- Altamont Commuter Express (ACE)/Valley Transit Authority (VTA) – San Jose Altamont Commuter Express

To obtain an estimated cost per vehicle revenue mile and revenue hour in the MAG region operating costs from the National Transit Database for bus service provided in each of the four metropolitan regions noted above were first compared to 2001 bus operating cost figures for Valley Metro/RPTA ($96.52 per vehicle hour and $6.26 per vehicle mile in 2001). The percentage difference in bus operating costs between each of the outside agencies and Valley Metro/RPTA was then applied to the commuter rail operating costs from each region to estimate a comparable difference in cost for a proposed MAG region commuter rail system. The four estimated operating costs were then averaged to obtain a single estimated cost per revenue service hour and revenue service mile for commuter rail in the MAG region. Table 8-6 summarizes the cost differences between each commuter rail provider.

Table 8-6 **Commuter Rail Operating Cost Comparison**

Metropolitan Area	Bus Revenue Hour Cost	Bus Revenue Mile Cost	Commuter Rail Revenue Hour Cost	Commuter Rail Revenue Mile Cost	Valley Metro/RPTA Average Difference (Bus)
Dallas	$99.84	$7.50	$545.51	$28.65	-9.9%
San Diego	$74.37	$4.33	$460.08	$11.05	37.2%
San Jose	$130.93	$10.22	$504.48	$14.00	-32.5%
Valley Metro	$96.52	$6.26			
MAG Average			$487.64	$16.81	

Table 8-7 summarizes the estimated operating costs for the four commuter rail corridors. All figures are in Year 2001 dollars.

Table 8-7 **Commuter Rail Operating Cost Comparison**

Commuter Rail Corridor	Preliminary Annual O&M Cost ($ millions)	Revised Annual O&M Cost ($ millions)	Change in O&M Cost (MS 4 to MS 5)
BNSF Phase 1	$3.45	$4.90	$1.45

Commuter Rail Corridor	Preliminary Annual O&M Cost ($ millions)	Revised Annual O&M Cost ($ millions)	Change in O&M Cost (MS 4 to MS 5)
BNSF Phase 3	$18.25	$22.55	$4.30
UP Mainline/Chandler Phase 1	$2.00	$1.85	-$0.15
UP Mainline/Chandler Phase 3	$14.05	$14.25	$0.20
UP Southeast Phase 1	$4.65	$3.05	-$1.60
UP Southeast Phase 3	$21.60	$17.50	-$4.10
UP Yuma Phase 1	$2.80	$3.60	$0.80
UP Yuma Phase 3	$19.95	$22.4	$2.45

Note: All costs are in Year 2001 dollars.

Alternative Commuter Rail Operating Scenarios

An outcome of the preliminary cost and ridership forecasts in Milestone 4 was a series of alternatives to explore more cost-effective ways of implementing commuter rail service in the MAG region. These options include variations of ownership of the freight corridor, the utilization of operating windows, and an exploration into the use of diesel multiple unit trains.

Freight Track Ownership Options

Section 6 includes a discussion of several models for rail right-of-way ownership. The cost estimates developed above assumed a combination of two ownership models. The purchase of a portion of each freight railroad corridor was assumed to operate the Phase 3 service, while access rights are leased in Phase 1 and on certain lower demand portions of corridors in Phase 3. Phase 1 also assumed improvements to the existing freight rail infrastructure, including, but not limited to, a second main track, signals, and sidings. The revised cost estimates below explore the implications of using operating windows for commuter rail trains assigned to run during peak periods to reduce capital costs during the initial start-up of commuter rail service. The use of operating windows provided by the freight operators would create an opportunity for delaying the construction of additional rail infrastructure in the corridors. These Phase 1 costs are based upon the 2020 ridership levels noted above.

These alternative cost estimates have been prepared for three of the commuter rail corridors: BNSF, UP Mainline/Chandler, and UP Southeast. Each of these new estimates assumes the lease of track rights within specific operating windows during the a.m. and p.m. peak periods. In all cases, these operating windows would require minimal or no freight rail service operating in the corridors. This would allow the commuter rail trains to operate at acceptable speeds and maintain scheduling. No estimate for the UP Yuma corridor is provided here because all phases of service implementation in this corridor assume the lease of track rights and no additional main track. This corridor experiences a much lower level of freight railroad traffic than the portion of the Union Pacific line east of Phoenix because of the closure of the corridor west of Palo Verde to Yuma. In effect, the UP Yuma corridor operates more like a branch line than a mainline. The reduced amount of traffic along this portion of the line allows for the implementation of commuter rail service with only the addition of a two-mile siding for freight car switching activities.

According to BNSF, the establishment of operating windows in the BNSF corridor would require the relocation of the freight rail facilities near downtown Phoenix to a location north of El Mirage. The cost estimates produced below do not include the cost of this relocation since predicting the public cost of this relocation is not possible until extensive negotiations with BNSF have occurred.

These alternatives involve the lease of rights during the Phase 1 start-up service. The construction of a second main track, implementation of Centralized Traffic Control (CTC) signals, and the purchase of the underlying right-of-way have been deferred to the Phase 3 level of service. The benefit of this proposal is the implementation the second main track over a longer period of time, allowing for the identification of sufficient funding and growth in ridership. The capital and operating costs for implementing this option are summarized in Table 8-8. Operating costs have not changed because the lease of rights for using the second main track was assumed in the original cost estimate.

Table 8-8 **Commuter Rail Track Lease Options**

Corridor	New Capital Cost ($ millions)	New Annual Operating Cost ($ millions)	Cost Effectiveness with Lease	Standard Investment Cost Effectiveness
Option 1 (Lease only in Phase 1)				
BNSF	$174.05	$4.90	$25.81	$38.78
UP Mainline/Chandler	$178.81	$1.85	$78.50	$113.92
UP Southeast	$178.69	$3.05	$58.70	$83.51

Note: These costs do not assume the cost for relocating the BNSF freight yard. The Standard Investment is considered to be a second main track consistent with the cost estimate contained in Table 8-5 above. Note: All costs are in Year 2001 dollars.

Another alternative for implementing service in the BNSF or UP corridors is the purchase of the entire freight rail right-of-way, with the freight rail operator(s) then leasing rights to use the track owned by MAG or another public agency in the MAG region. This alternative would likely increase the initial capital cost of the service due to the cost of purchasing the rail right-of-way. Long-term operating costs would be reduced since the commuter rail agency would receive an annual lease payment from the freight operator for the use of the tracks. However, this long-term cost savings would not likely offset the initial capital cost of purchasing the corridor. The benefit of this arrangement would be that the commuter rail operating agency would be in control of dispatching and scheduling. This scenario is dependent upon the freight railroad operations being willing to sell their right-of-way. The potential for this scenario is not known at this time, making it difficult to develop an accurate cost estimate for this scenario.

Diesel Multiple Unit Technology

All of the recent "New Starts" commuter rail operations that have become operational in the last 10 years share a similar vehicle technology consisting of diesel locomotive-hauled trains operated in a push-pull configuration. West Coast commuter rail providers not only share train technologies, but also manufacturers. The one commuter rail agency to deviate from this technology was the Trinity Railway Express in Dallas, Texas. This agency has operated Budd Rail Diesel Cars (RDC) during the initial implementation of commuter service between Dallas and Fort Worth.

Recently, a new type of commuter rail technology has been implemented in North America. The Diesel Multiple Unit (DMU) rail vehicle has been successfully used in Europe for many years, but had not appeared in North America due to the inability of existing designs to meet Federal Railroad Administration (FRA) safety regulations. The Ottawa O-Train utilizes Bombardier Talent DMUs with an operating waiver from the Canadian Government.

Another manufacturer, Colorado Rail Car, has announced that they have designed a DMU vehicle that meets FRA safety regulations. Given the long-term nature of this study, it is reasonable to explore a scenario where both the Talent and the Colorado Rail Car DMUs are fully certified by the FRA for use in mixed freight and passenger corridors. Research into the current Federal Transit Administration's New Starts process has revealed that two public agencies have submitted DMU-based commuter rail projects to the Federal funding process. These DMU systems are proposed in Raleigh-Durham, North Carolina and Tampa, Florida. Both projects are in the Preliminary Engineering phase.

DMUs possess several operational advantages over conventional locomotive trains. The DMU vehicles are usually less expensive than a comparable locomotive-hauled unit on a per passenger basis, are more fuel-efficient, and are capable of quicker acceleration and deceleration rates thanks to lower overall weight. Disadvantages include the need for additional vehicles if single-level vehicles are selected, possible increases in maintenance costs due to the relative uniqueness of the technology in North America, and possible early replacement of vehicles and limited life cycle. Several European train operators have been replacing Talent vehicles after 10 to 15 years of revenue service, while standard locomotive-hauled coaches will operate for approximately 30 years.

Capital and operating costs have been developed for the implementation of commuter rail service using DMU trains. Table 8-9 summarizes the capital cost of implementing DMU service with each of the two vehicles described above along with a comparison to the conventional locomotive cost estimates.

Table 8-10 **DMU Capital Cost Table**

Corridor	Colorado Rail Car DMU ($ millions)	Bombardier Talent DMU ($ millions)	Conventional Locomotive ($ millions)
BNSF Phase 1	$302.54	$299.76	$292.30
BNSF Phase 3	$426.15	$430.32	$445.63
BNSF Total	**$728.69**	**$730.08**	**$737.93**
UP Mainline/Chandler Phase 1	$253.04	$251.78	$269.93
UP Mainline/Chandler Phase 3	$229.05	$203.88	$260.29
UP Mainline/Chandler Total	**$482.10**	**$455.66**	**$530.22**
UP Southeast Phase 1	$257.58	$250.62	$270.34
UP Southeast Phase 3	$259.58	$266.54	$297.15
UP Southeast Total	**$517.16**	**$517.16**	**$567.50**
UP Yuma Phase 1	$129.72	$129.78	$143.25
UP Yuma Phase 3	$302.86	$319.56	$308.55
UP Yuma Total	**$432.58**	**$449.27**	**$451.80**

Note: Phase 1 costs for all three technologies are derived from 2020 ridership projections. All costs are in Year 2001 dollars.

Operating costs for the Colorado Rail Car DMU were estimated using the operating cost estimates developed for the Sonoma-Marin Commuter Rail Study (SMART). The SMART study involves a 68-mile corridor with initial service of 4 trains per day (3 peak and 1 off-peak) between Sonoma and Marin counties in the San Francisco Bay Area of Northern California.

Operating costs for commuter rail service with the Bombardier Talent DMU were developed using the results of an evaluation report produced in December 2002 by OC Transpo for the City of Ottawa. The annual operating cost for this service was then converted to US Dollars using a $0.65 conversion rate. Table 8-11 summarizes the estimated annual revenue mile and revenue hour costs used for the three commuter rail vehicles to estimate annual operating costs. Operating costs are then summarized for the three technologies in Table 8-12. Cost effectiveness results for the three commuter rail vehicle technologies are compared in Table 8-13. This cost effectiveness figure is for the Phase 3 level of service.

Table 8-11 **DMU Annual Revenue Mile and Hour Costs**

Vehicle	Annual Cost per Revenue Service Mile	Annual Cost per Revenue Service Hour
Conventional Locomotive-Hauled	$16.81	$487.64
Colorado Rail Car DMU	$14.32	$395.11
Bombardier Talent DMU	$10.56	$209.98

Note: All costs are in Year 2001 dollars.

Table 8-12 **DMU Operating and Maintenance Cost Comparison**

Corridor	Colorado Rail Car DMU ($ millions)	Bombardier Talent DMU ($ millions)	Conventional Locomotive ($ millions)
BNSF Phase 1	$3.45	$3.94	$4.90
BNSF Phase 3	$21.15	$20.60	$22.55
UP Mainline/Chandler Phase 1	$1.55	$1.49	$1.85
UP Mainline/Chandler Phase 3	$12.71	$8.46	$14.25
UP Southeast Phase 1	$2.64	$2.31	$3.05
UP Southeast Phase 3	$14.54	$14.17	$17.50
UP Yuma Phase 1	$2.42	$2.59	$3.60
UP Yuma Phase 3	$20.69	$19.78	$22.40

Note: All costs are in Year 2001 dollars.

Table 8-13 **DMU Cost Effectiveness Comparison**

Corridor	Colorado Rail Car DMU Cost Effectiveness	Bombardier Talent DMU Cost Effectiveness	Conventional Locomotive Cost Effectiveness
BNSF Phase 3	$16.40	$16.31	$16.84
UP Mainline/Chandler Phase 3	$37.48	$32.82	$41.41
UP Southeast Phase 3	$30.07	$29.87	$33.83
UP Yuma Phase 3	$15.32	$15.43	$16.22

Note: All costs are in Year 2001 dollars.

As shown in the two tables above, DMU technology does offer a potentially cost-effective alternative to conventional locomotive-hauled commuter trains. The relative uniqueness of the DMU technology in North America may create some procurement and maintenance issues. However, as the technology becomes more prevalent, these additional risks and costs will be minimized. Given the long-term horizon of this study it remains prudent to retain DMU technology as a possible option for providing commuter rail service in the MAG region. The selection of a specific technology for commuter rail in a selected freight corridor in the MAG region would require a detailed Major Investment Study (MIS).

8.3 Light Rail/Bus Rapid Transit Ridership

Several additional corridors in the MAG region have been identified for potential high capacity transit service in addition to the four commuter rail corridors noted above. These corridors would likely contain a light rail transit (LRT) or bus rapid transit (BRT) system. For the purposes of this report BRT is defined as buses running in an exclusive right-of-way located either in a street or freeway median, and is referred to as Dedicated BRT. Express BRT services operating in freeway high occupancy vehicle (HOV) lanes were included in the initial set of corridors. The outcome of the evaluation of the Express BRT corridors is described later in the report.

Ridership estimates in these corridors have been determined using a single centerline alignment chosen as a representative for each corridor. These representative alignments will be use to identify each corridor in this report. Parallel alignments within each corridor could be considered as a final alignment for high capacity transit service.

Similarly to the commuter rail forecasts, a direct demand modeling approach was used, in this case the MAG Sketch Plan Model, which was selected as a tool for the rapid development of corridor forecasts. The model is developed from trip rates on existing LRT systems in San Diego, Sacramento and Portland. These cities are believed to be representative of Phoenix being of similar size with comparable development patterns and densities.

The existing LRT systems were used to determine trip rate factors based on access and egress distance. To apply the trip rate factors it is necessary to determine the number of households and jobs within the four distance bands of the LRT stations, namely 0-0.25 miles, 0.25-0.5 miles, 0-2 miles and 2-5 miles. Trips within 0.5 miles are assumed to represent the walk access/egress catchment, with those up to 5 miles representing motorized access.

The networks identified in Section 7 were used as the basis for developing the initial set of corridors. Modifications have been made to several corridors in terms of alignment and limits as a result of comments from local agencies and consolidations of parallel or overlapping corridors. These revisions to the proposed LRT/Dedicated BRT network are explained in detail later in this report. Table 8-14 provides a summary of the new corridor limits and alignments.

Table 8-14 **LRT/Dedicated BRT Corridor Refinements**

Corridor	Previous Limits	Revised Limits	Reason for Alignment Changes
59th Avenue	51st Ave/Baseline Rd to 59th Ave/Bell Rd	Same	n/a
Bell Road	Loop 303 to Scottsdale Road	Same	n/a

Corridor	Previous Limits	Revised Limits	Reason for Alignment Changes
Camelback Road	Loop 101 West Valley to Scottsdale Road	Central Avenue to Scottsdale Road	Western portion consolidated with Glendale Avenue
Central Avenue South	n/a	Baseline Road to CP/EV LRT alignment	New corridor
Chandler Boulevard	Ray Road to Power Road	Same	n/a
Glendale Avenue (formerly Northern Avenue)	Northern/19th Avenue to Northern/Loop 101 West	Glendale/I-17 to Glendale/Loop 101 west	Consolidated with Camelback corridor, serve Glendale sports facility at Loop 101
I-10 West	Central Ave/Van Buren to I-10/Loop 101 West	Same	n/a
Main Street	CP/EV Terminus to Power Road	Same	n/a
Metrocenter/I-17	19th/Bethany Home to Metrocenter Mall (Peoria Ave/I-17)	19th/Bethany Home to Bell/I-17	Matches City of Phoenix Long Range LRT plan
Power Road	Power/Williams Field to McDowell/Higley	Same	n/a
Scottsdale Road/Rural Road	Bell Rd/Scottsdale Rd to Price Rd/Queen Creek Rd	Bell Rd/Scottsdale Rd to UP Tempe Branch southern terminus	Southern portion consolidated with UP Tempe Branch
SR-51	Central Ave/Camelback Rd to Tatum/Loop 101	Central Ave/Indian School to Tatum/Loop 101	Match alignment to City of Phoenix Long Range LRT plan
Union Pacific Chandler Branch	Price Rd/Queen Creek Rd to UP Mainline	Price Rd/Queen Creek Rd to Main St/Mesa Rd	Connect to Main Street Corridor
Union Pacific Tempe Branch	UP Mainline (Tempe Junction) to southern terminus (56th St/I-10)	None	Consolidated with Scottsdale/Rural corridor

As was the case with commuter rail ridership estimates, LRT/Dedicated BRT ridership estimates were developed in a two stage process in order to incorporate the MAG Draft 2 population and employment forecasts. Station spacing is assumed to be one mile on average, a figure consistent with other West Coast LRT systems and the majority of Central Phoenix/East Valley (CP/EV) LRT system.

Updated forecasts are shown below in Table 8-15. Note that five corridors have also been evaluated as extensions of the proposed Central Phoenix and East Valley (CP/EV) LRT line to give some indication of the benefit of through-running service. These extension figures were not used in any of the evaluation processed contained later in the report. They are presented solely for reference. Where possible, the change from the initial forecasts is shown, but for a number of corridors the changes to the network are too large for comparison.

An additional corridor included in the ridership table is a hybrid Express/Dedicated BRT service on Grand Avenue. This service was analyzed at the request of several cities in the Grand Avenue corridor as an alternative technology if commuter rail was deemed infeasible. The BRT service proposed involves buses operating in mixed-flow traffic for a majority of the route. Exclusive queue jumping lanes are proposed at all signalized intersections, along with signal priority systems. This type of operation is not as efficient as a full Dedicated BRT service, but is a substantial upgrade above standard bus service.

Table 8-15

Updated LRT/BRT Ridership Projections

Corridor	Length	Estimated Average Daily boardings	Boardings per mile	Percent Change from Initial
59th Avenue	19	12,829	675	-36%
Bell Road	29	19,750	691	-33%
Camelback	9	8,126	945	-21%
Central Avenue South	5	5,749	1,150	n/a
Chandler Boulevard	17	12,226	741	1%
Glendale	10	7,226	737	n/a
I-10 West	11	13,765	1,251	32%
Main Street	10	9,697	1,010	-6%
Metrocenter/I-17	9	8,848	1,005	n/a
Power Road	13	8,653	666	-30%
Scottsdale Road/Tempe Branch	26	20,672	811	-15%
SR-51	17	12,334	713	23%
UP Chandler Branch	13	12,534	995	-29%
As extensions				
Metrocenter/I-17	9	14,178	1,611	-4%
Central Avenue South	5	6,316	1,263	n/a
Glendale Avenue	10	8,753	893	n/a
SR-51	17	18,046	1,043	n/a
Main Street	10	16,246	1,692	n/a
Alternative scenarios				
Grand Avenue	26	11,770	456	n/a

Notes: Metrocenter was only forecasted as an extension in Milestone 4. For more detail on alignment changes see Table 8-14.

Most of the LRT projections have declined from those originally developed for Milestone 4. Refinements to station intervals reduced ridership forecasts by up to 20 percent, with the remainder of the ridership difference due to corridor definition changes and population and employment projection changes.

8.4 Light Rail Transit Capital and Operating Costs

All LRT costs are based upon average unit rates for various light rail projects designed in the western United States. These cost estimates are planning level estimates that have been produced without the benefit of detailed plans. More precise costs would be produced in the latter stages of project design and development.

Capital Cost Estimates

Table 8-16 summarizes the capital cost estimates for each of the potential LRT corridors.

Table 8-16 **LRT Cost Comparison Table**

LRT Corridor	Initial Capital Costs ($ millions)	Refined Capital Costs ($ millions)	Change in Capital Costs
59th Avenue	$767.58	$727.81	-$39.77
Bell Road	$1,137.65	$1,102.24	-$35.41
Camelback Road	$881.03	$349.36	-$531.67
Central Avenue South	n/a	$228.03	n/a
Chandler Boulevard	$651.89	$683.75	$31.86
Glendale Avenue	$248.87	$429.22	$180.35
I-10 West	$388.58	$399.34	$10.76
Main Street	$360.49	$373.63	$13.14
Metrocenter/I-17	$220.04	$337.65	$117.61
Power Road	$498.20	$465.10	-$33.1
Scottsdale Road	$1,244.02	$1,010.84	-$233.18
SR-51	$837.67	$823.28	-$14.39
Union Pacific Chandler Branch	$495.97	$460.86	-$35.11

Notes: The Glendale Avenue MS 4 cost is for Northern Avenue east of Grand Ave. The UP Tempe Corridor was combined with the Scottsdale Corridor, so the capital costs for UP Tempe are not presented here. All costs are in Year 2001 dollars.

Table 8-17 Light Rail Capital Cost Summary

Item	59th Avenue	Bell Road	Camelback Road	Central Avenue South	Chandler Boulevard	Glendale Avenue	I-10 West	Main Street	Metrocenter	Power Road	Scottsdale Road	SR-51	Union Pacific Chandler Branch
Corridor Length (miles)	18.99	28.55	8.63	4.93	16.45	9.75	11.05	9.64	8.57	13.04	25.55	17.34	12.60
Subtotal-Civil Site Mods	$30,623,475	$46,068,200	$14,460,650	$8,240,360	$24,023,900	$14,968,000	$16,671,100	$16,611,225	$12,400,000	$21,521,600	$35,044,000	$19,239,625	$6,649,000
Subtotal-Guideway	$59,824,711	$57,522,832	$18,699,834	$25,921,714	$76,783,124	$40,108,440	$15,656,856	$9,438,841	$17,705,140	$22,498,116	$80,841,180	$132,328,105	$16,287,072
Subtotal-Utilities	$42,622,825	$64,076,400	$19,365,550	$11,062,920	$36,922,300	$21,879,000	$24,796,200	$21,632,075	$19,635,000	$29,267,200	$57,222,000	$38,910,875	$28,274,400
Subtotal-Track	$37,720,905	$54,663,360	$16,733,070	$10,466,088	$33,289,020	$19,629,000	$20,913,980	$18,205,155	$16,426,800	$24,815,880	$50,311,200	$36,543,675	$25,688,160
Subtotal-Stations	$41,525,000	$61,775,000	$20,575,000	$9,375,000	$42,375,000	$24,950,000	$21,225,000	$19,350,000	$18,100,000	$25,975,000	$48,675,000	$44,275,000	$25,575,000
Subtotal-Systems & Electrical	$91,047,948	$138,079,226	$42,032,162	$23,736,523	$79,375,582	$47,058,010	$53,290,308	$46,918,268	$40,874,450	$62,750,448	$121,622,380	$81,609,960	$61,397,896
Subtotal - Facilities	$7,500,000	$12,500,000	$5,500,000	$4,500,000	$7,500,000	$6,250,000	$5,500,000	$7,000,000	$3,500,000	$5,500,000	$12,000,000	$9,000,000	$7,250,000
A. Construction Subtotal	**$310,864,864**	**$434,685,018**	**$137,366,266**	**$93,302,604**	**$300,268,926**	**$174,842,450**	**$158,053,444**	**$139,155,564**	**$128,641,390**	**$192,328,244**	**$405,715,760**	**$361,907,240**	**$171,121,528**
Environmental Mitigation	$6,217,297	$8,693,700	$2,747,325	$1,866,052	$6,005,379	$3,496,849	$3,161,069	$2,783,111	$2,572,828	$3,846,565	$8,114,315	$7,238,145	$3,422,431
B. Construction Cost Subtotal	**$317,082,161**	**$443,378,718**	**$140,113,591**	**$95,168,656**	**$306,274,305**	**$178,339,299**	**$161,214,513**	**$141,938,675**	**$131,214,218**	**$196,174,809**	**$413,830,075**	**$369,145,385**	**$174,543,959**
C. Right of Way Subtotal	**$62,051,975**	**$101,652,400**	**$30,108,250**	**$13,527,480**	**$51,746,100**	**$30,999,000**	**$25,237,200**	**$35,506,425**	**$32,274,100**	**$46,816,900**	**$84,524,000**	**$47,870,025**	**$49,176,700**
D. Vehicles Subtotal	**$66,975,000**	**$141,712,500**	**$48,141,750**	**$34,109,250**	**$59,801,250**	**$58,293,750**	**$65,175,000**	**$58,044,000**	**$48,225,000**	**$42,525,000**	**$131,137,500**	**$89,701,500**	**$65,535,000**
Cost Contingencies (Uncertainties, Changes)													
Design&Construction	$79,270,540	$110,844,680	$35,028,398	$23,792,164	$76,568,576	$44,584,825	$40,303,628	$35,484,669	$32,803,554	$49,043,702	$103,457,519	$92,286,346	$43,635,990
Right of Way	$18,615,593	$30,495,720	$9,032,475	$4,058,244	$15,523,830	$9,299,700	$7,571,160	$10,651,928	$9,682,230	$14,045,070	$25,357,200	$14,361,008	$14,753,010
Vehicle Cost	$6,697,500	$14,171,250	$4,814,175	$3,410,925	$5,980,125	$5,829,375	$6,517,500	$5,804,400	$4,822,500	$4,252,500	$13,113,750	$8,970,150	$6,553,500
Program Implementation (Agency Costs and Fees)													
Design&Construction	$98,295,470	$137,447,403	$43,435,213	$29,502,284	$94,945,034	$55,285,183	$49,976,499	$44,000,989	$40,676,408	$60,814,191	$128,287,323	$114,435,069	$54,108,627
Right of Way Purchase	$9,307,796	$15,247,860	$4,516,238	$2,029,122	$7,761,915	$4,649,850	$3,785,580	$5,325,964	$4,841,115	$7,022,535	$12,678,600	$7,180,504	$7,376,505
Vehicle Procurement	$3,348,750	$7,085,625	$2,407,088	$1,705,463	$2,990,063	$2,914,688	$3,258,750	$2,902,200	$2,411,250	$2,126,250	$6,556,875	$4,485,075	$3,276,750
E. Capital Cost Subtotal	**$661,644,785**	**$1,002,036,156**	**$317,597,177**	**$207,303,588**	**$621,591,198**	**$390,195,669**	**$363,039,830**	**$339,659,250**	**$306,950,375**	**$422,820,957**	**$918,942,842**	**$748,435,062**	**$418,960,040**
Project Reserve	$66,164,479	$100,203,616	$31,759,718	$20,730,359	$62,159,120	$39,019,567	$36,303,983	$33,965,925	$30,695,037	$42,282,096	$91,894,284	$74,843,506	$41,896,004
F. Total Capital Cost	**$727,809,264**	**$1,102,239,771**	**$349,356,895**	**$228,033,946**	**$683,750,317**	**$429,215,236**	**$399,343,813**	**$373,625,175**	**$337,645,412**	**$465,103,053**	**$1,010,837,127**	**$823,278,568**	**$460,856,044**

Note: All costs are in 2001 Dollars. Detailed cost information can be found in Appendix B.

LRT Operating Cost Estimates

Light rail operating costs have estimated using a parametric model developed for the Tri-Met LRT system in Portland, Oregon. The model includes the number of stations, length of the alignment, number of vehicles in the fleet, vehicle service hours, and vehicle service miles. Model inputs have been adjusted by comparing bus operating costs for Valley Metro/RPTA with Tri-Met bus service. The use of these model inputs eliminates the need for comparisons between multiple light rail systems as was the case in developing commuter rail operating costs. Instead, the parametric model is designed to produce consistent results even when applied to different light rail systems in different metropolitan areas because the model is based upon the bus service costs within the metropolitan region. Operating costs are the same whether the light rail system is run on ballasted or embedded track. Table 8-18 summarizes the operating costs for 13 LRT corridors. Costs are in Year 2001 dollars. Detailed LRT operating costs are provided in Appendix B.

Table 8-18 **Light Rail Operating and Maintenance Costs**

LRT Corridor	Initial Annual O&M Cost ($ millions)	Refined Annual O&M Cost ($ millions)	Change in O&M Cost
59th Avenue	$11.35	$11.29	-$0.06
Bell Road	$22.58	$22.55	-$0.03
Camelback Road	$17.12	$7.63	-$9.49
Central Avenue South	n/a	$4.83	n/a
Chandler Boulevard	$9.79	$9.74	-$0.05
Glendale Avenue	$6.13	$8.96	$2.83
I-10 West	$6.79	$10.29	$3.50
Main Street	$8.96	$8.96	$0.00
Metrocenter/I-17	$4.93	$7.61	$2.68
Power Road	$7.22	$8.26	$1.04
Scottsdale Road	$22.58	$20.95	-$1.63
SR-51	$14.16	$14.34	$0.18
Union Pacific Chandler Branch	$10.44	$10.44	$0.00

Note: The Glendale Avenue costs have been compared to the Northern Avenue east of Grand Ave. costs from Milestone 4. All costs are in Year 2001 dollars.

8.5 Bus Rapid Transit Capital and Operating Costs

Dedicated BRT operates at-grade in an exclusive lane in arterial street and rail right-of-way corridors. The BRT service would be similar to light rail in terms of type of service and system cross-section, but with smaller vehicles requiring higher frequencies to provide a comparable level of service. Consistent with the LRT capital cost estimates, a 27-foot wide cross-section is assumed to accommodate the new exclusive BRT lanes on arterial streets. The cost estimates for Dedicated BRT assume the replacement of any mixed-flow automobile lanes that are removed to accommodate the new BRT lanes.

Dedicated BRT assumes stations on average one mile apart. Refinements to the potential Dedicated BRT corridors reflect the consolidation of selected corridors, revised alignments, and modifications to unit cost values used the capital cost estimates. Capital and operating and maintenance cost estimates have been produced for nine potential Dedicated BRT corridors. Corridors which are not presented here, Metrocenter/I-17, Central Avenue South, Glendale Avenue, and I-10 West, have only been analyzed as LRT corridors.

The cost estimates below include a scenario for a hybrid Express/Dedicated BRT service along Grand Avenue. This service was analyzed at the request of several cities as an alternative technology in the event that commuter rail was not feasible. As noted above, the buses in this corridor will not operate in a fully exclusive lane. Instead, travel times and operations will be enhanced by the presence of queue jumping lanes at signalized intersections.

Dedicated BRT Capital Costs

A major distinction in the capital cost estimates for the Dedicated BRT corridors involves the assumption that the BRT guideway will be paved with concrete rather than asphalt. This assumption was made based upon the results of BRT implementation in other cities in North America and Agency Working Group input.

Table 8-19 provides a comparison between the initial and refined capital costs. Details on the capital costs are presented in Table 8-20 and in Appendix C. All costs are presented in Year 2001 dollars.

Table 8-19 **BRT Capital Cost Comparison Table**

LRT Corridor	Initial Capital Costs ($ millions)	Revised Capital Costs ($ millions)	Change on Capital Cost
59th Avenue	$288.67	$359.08	$70.41
Bell Road	$408.93	$539.11	$130.18
Camelback Road	$311.29	$165.65	-$145.64
Chandler Boulevard	$242.75	$306.02	$63.27
Main Street	$142.64	$184.71	$42.07
Power Road	$189.78	$236.83	$47.05
Scottsdale Road	$449.24	$465.96	$16.72
SR-51	$183.45	$254.67	$71.22
Union Pacific Chandler Branch	$204.82	$225.92	$21.10
Grand Avenue	n/a	$232.48	n/a

Notes: The initial costs presented for SR-51 are the Glendale Ave/Cactus Ave costs produced in Milestone 4. No Dedicated BRT costs were produced initially for the SR-51 corridor.

Table 8-20 Bus Rapid Transit Capital Cost Summary

Item	59th Avenue	Bell Road	Camelback Road	Chandler Boulevard	Main	Power Road	Scottsdale Road	SR-51	Union Pacific Chandler Branch	Grand Avenue
Corridor Length (miles)	18.99	28.55	20.88	16.45	9.64	13.04	28.10	17.34	11.13	25.80
Subtotal-Civil/Roadway	$42,424,191	$60,883,898	$19,011,231	$35,588,540	$21,004,746	$27,775,902	$49,293,376	$24,536,921	$18,338,604	$18,696,143
Subtotal-Utilities	$35,101,150	$52,769,150	$15,948,100	$30,406,600	$17,814,650	$24,102,400	$47,124,000	$21,418,250	$23,284,800	$19,950,000
Subtotal-Stations	$30,827,500	$47,052,500	$14,602,500	$27,582,500	$16,225,000	$21,092,500	$40,562,500	$27,582,500	$21,092,500	$21,092,500
Subtotal-Systems & Electrical	$17,625,798	$26,477,026	$8,213,222	$15,258,170	$9,080,986	$11,742,909	$23,428,500	$13,293,236	$11,756,000	$18,031,500
Subtotal Facilities	$6,600,000	$7,950,000	$3,150,000	$3,900,000	$3,450,000	$2,700,000	$7,200,000	$5,250,000	$4,050,000	$9,650,000
A. Construction Subtotal	**$132,578,639**	**$195,132,573**	**$60,925,053**	**$112,735,811**	**$67,575,382**	**$87,413,711**	**$167,608,376**	**$92,080,907**	**$78,521,904**	**$87,420,143**
Environmental Mitigation	$2,651,573	$3,902,651	$1,218,501	$2,254,716	$1,351,508	$1,748,274	$3,352,168	$1,841,618	$1,570,438	$1,748,403
B. Construction Cost Subtotal	**$135,230,212**	**$199,035,225**	**$62,143,554**	**$114,990,527**	**$68,926,890**	**$89,161,985**	**$170,960,544**	**$93,922,525**	**$80,092,342**	**$89,168,545**
C. Right of Way Subtotal	**$68,123,975**	**$106,206,975**	**$31,626,250**	**$60,854,100**	**$35,506,425**	**$48,334,900**	**$92,470,500**	**$47,870,025**	**$47,796,700**	**$33,175,600**
D. Vehicles Subtotal	**$14,520,000**	**$22,264,000**	**$6,776,000**	**$9,196,000**	**$7,744,000**	**$5,324,000**	**$19,844,000**	**$13,552,000**	**$9,680,000**	**$20,988,000**
Cost Contingencies (Uncertainties, Changes)										
Design&Construction	$33,807,553	$49,758,806	$15,535,889	$28,747,632	$17,231,722	$22,290,496	$42,740,136	$23,480,631	$20,023,086	$22,292,136
Right of Way	$20,437,193	$31,862,093	$9,487,875	$18,256,230	$10,651,928	$14,500,470	$27,741,150	$14,361,008	$14,339,010	$9,952,680
Vehicle Cost	$1,452,000	$2,226,400	$677,600	$919,600	$774,400	$532,400	$1,984,400	$1,355,200	$968,000	$2,098,800
Program Implementation (Agency Costs and Fees)										
Design&Construction	$41,921,366	$61,700,920	$19,264,502	$35,647,063	$21,367,336	$27,640,215	$52,997,769	$29,115,983	$24,828,626	$27,642,249
Right of Way Purchase	$10,218,596	$15,931,046	$4,743,938	$9,128,115	$5,325,964	$7,250,235	$13,870,575	$7,180,504	$7,169,505	$4,976,340
Vehicle Procurement	$726,000	$1,113,200	$338,800	$459,800	$387,200	$266,200	$992,200	$677,600	$484,000	$1,049,400
E. Capital Cost Subtotal	**$326,436,894**	**$490,098,664**	**$150,594,407**	**$278,199,067**	**$167,915,864**	**$215,300,901**	**$423,601,274**	**$231,515,475**	**$205,381,269**	**$211,343,751**
Project Reserve	$32,643,689	$49,009,866	$15,059,441	$27,819,907	$16,791,586	$21,530,090	$42,360,127	$23,151,547	$20,538,127	$21,134,375
F. Total Capital Cost	**$359,080,584**	**$539,108,531**	**$165,653,848**	**$306,018,974**	**$184,707,451**	**$236,830,991**	**$465,961,401**	**$254,667,022**	**$225,919,396**	**$232,478,126**

Note: All costs are in 2001 Dollars. Detailed cost information can be found in Appendix C.

Dedicated BRT Operating and Maintenance Costs

Table 8-21 summarizes the annual operating and maintenance costs for the nine potential BRT corridors. These costs are based upon the report Year 2001 bus operating costs for Valley Metro/RPTA. Costs are in Year 2001 dollars. Estimated operating and maintenance costs for these corridors initially are also presented here for reference. Detailed operating and maintenance cost estimates can be found in Appendix C.

Table 8-21 **Dedicated BRT Operating and Maintenance Costs**

Dedicated BRT Corridor	Initial Annual O&M Cost ($ millions)	Revised Annual O&M Cost ($ millions)	Change in O&M Cost
59th Avenue	$10.29	$10.29	$0.00
Bell Road	$15.64	$15.64	$0.00
Camelback Road	$11.53	$4.91	-$6.62
Chandler Boulevard	$6.59	$6.59	$0.00
Main Street	$5.35	$5.35	$0.00
Power Road	$3.71	$3.71	$0.00
Scottsdale Road	$15.23	$14.00	-$1.23
SR-51	$10.71	$9.47	-$1.24
Union Pacific Chandler Branch	$7.41	$7.00	-$0.41
Grand Avenue	n/a	$15.91	n/a

Notes: The Milestone 4 costs presented for SR-51 are the Glendale Ave/Cactus Ave costs produced in Milestone 4. No Dedicated BRT costs were produced in Milestone 4 for the SR-51 corridor. All costs are in Year 2001 dollars.

Express BRT Corridors

The Express BRT corridors are not included in this evaluation for several reasons. Express BRT has dramatically different operating characteristics when compared to other forms of high capacity transit such as LRT and Dedicated BRT. Many Express BRT systems in North America operate only during peak commute times. Systems with service during off-peak periods operate a minimal amount of service, approximately every hour. These service levels are limited compared to projections of LRT and Dedicated BRT service in the MAG region with 5 to 10 minute headways in the peak periods and 15 to 20 minute service during off-peak times. Even the Phase 3 commuter rail service would provide more frequent service during both peak and off-peak times, while carrying more passengers per mile. The boarding figures projected for the Express BRT corridors achieve a maximum of 76 passengers per mile even with an assumed minimal off-peak service. This figure is noticeably less than the lowest boarding figure for a LRT/Dedicated BRT corridor of 666 passengers per mile.

The capital costs of these corridors are also not comparable to the other technologies since Express BRT requires a substantially lower amount of capital investment when compared to other forms of transit. The High Capacity Transit Study is designed to evaluate transit systems capable of being classified as Major Investment Studies (MIS). This type of study is undertaken by public agencies to analyze the benefits and costs of major transportation infrastructure projects such as an LRT system or a new freeway. The construction of an LRT or Dedicated BRT project studied as part of an MIS has a distinctly different set of benefits and trade-offs in terms of costs, riders, and corridor impacts when compared to implementing Express BRT service in an existing freeway corridor, requiring minimal capital improvements. These distinctive differences limit the ability of Express BRT to be compared to LRT and Dedicated BRT systems on an equal footing.

As a result of these distinctions in the ridership and cost characteristics of this technology, the Express BRT corridors were not included in further evaluation processes. However, the benefits of Express BRT including low capital cost and simple implementation are recognized in this study. Therefore, seven Express BRT corridors are recommended for incorporation into the base transit network. Further evaluation and refinement of these corridors has occurred as part of Valley Metro/RPTA's Regional Transit System Study. The seven Express BRT corridors are:

- I-10 Far West – Loop 101 to Loop 303
- I-17 – Loop 101 to Anthem Way
- Loop 101 East – I-17 to Queen Creek Road
- Loop 101 West – I-17 to Baseline Road (via 91st Avenue)
- Loop 202 – I-10/SR-51/Loop 202 Interchange to I-10 South Interchange
- Loop 303 – I-10 to Grand Avenue
- US-60 – I-10 to Idaho Road

8.6 Revenue Forecasts

The fare structure and fare levels for high capacity BRT, LRT and express bus services will need to be pegged to the existing Valley Metro/RPTA system, since these high capacity modes are similar or identical to Valley Metro/RPTA services. Public discussion has focused on the desirability of maintaining a seamless fare structure for all services operating under the Valley Metro/RPTA umbrella, extending as well to the Central Phoenix/East Valley LRT service. Commuter rail fare policies and fare levels can and should be different from the other transit modes. A more complex fare structure encompassing zone-based and off-peak fares is desirable. Fare levels for commuter rail should reflect a comparison to other peer systems, but also take into considerations such as the cost of living and propensity to use transit in the MAG region.

The average fare per passenger for the Valley Metro/RPTA system for the year ended June 30, 2001 was $0.66. This fare was used to develop revenue projections for the BRT, LRT, and express bus corridors shown in Table 8-22. It is essential to note that the revenue forecasts in this time are based upon the initial ridership and cost forecasts developed in Milestone 4. These figures do not correspond to the forecasts presented in Section 8. Instead, these figures can serve as a guide for possible revenues and farebox recovery rates.

Table 8-22 **Farebox Revenue Forecast: LRT and BRT Corridors**

Corridor	Length (Miles)	Estimated Daily Boardings	Mode	Annual Passengers	Annual Revenue at FY 2000 Valley Metro/RPTA Average Fare
59th Avenue	19	19,594	BRT/LRT	7,151,976	$4,720,304
Baseline Road	13	8,199	BRT/LRT	2,992,469	$1,975,029
Bell Road	28	28,661	BRT/LRT	10,461,159	$6,904,365
Camelback Road	20	24,020	BRT/LRT	8,767,384	$5,786,473
Chandler Boulevard	17	12,507	BRT/LRT	4,565,153	$3,013,001
Union Pacific Chandler Branch	12	19,490	BRT/LRT	7,113,668	$4,695,021
Glendale Avenue/Cactus Avenue	19	14,295	BRT/LRT	5,217,605	$3,443,619
Main Street	12	12,090	BRT/LRT	4,412,766	$2,912,426
Main Street	9	9,674	BRT/LRT	3,530,842	$2,330,356
Metrocenter/I-17	3	5,062	LRT	1,847,570	$1,219,396
Northern (East of Grand Ave)	6	7,266	LRT	2,652,219	$1,750,464
Northern (West of Grand Ave)	13	4,700	BRT/LRT	1,715,507	$1,132,235
Northern (Total)	19	11,966	BRT/LRT	4,367,726	$2,882,699
Power Road	11	10,496	BRT/LRT	3,831,214	$2,528,601
Scottsdale Road	29	27,182	BRT/LRT	9,921,518	$6,548,202
SR-51	16	9,988	LRT	3,645,505	$2,406,033
Union Pacific Tempe Branch	10	8,010	BRT/LRT	2,923,540	$1,929,537

The proposed commuter rail fare structure is presented in Table 8-23. It represents a balance between a reasonable full fare and appropriate levels of discounts for monthly pass users and off peak riders. Seniors, disabled, and youth are eligible for the discount fare. All passengers are eligible for the discount fare during off-peak hours.

Table 8-23 **Proposed Commuter Rail Fare Structure**

Mileage	Zone	Full Fare	Discount Fare At 55%	Monthly Pass At 30 Times Full Fare	Fare Per Mile (At Highest Mileage in Zone) Full Fare	Discount	Monthly/40
0-10	1	$2.75	$1.50	$82.50	$0.28	$0.15	$0.21
10-15	2	$3.25	$1.75	$97.50	$0.22	$0.12	$0.16
15-20	3	$4.00	$2.25	$120.00	$0.20	$0.11	$0.15
20-30	4	$5.00	$2.75	$150.00	$0.17	$0.09	$0.13
30-40	5	$6.25	$3.50	$187.50	$0.16	$0.09	$0.12
40-50	6	$7.00	$3.75	$210.00	$0.14	$0.08	$0.11
Over 50	7	$7.50	$4.00	$225.00	$0.14	$0.08	$0.11

Table 8-24 provides the resulting annual revenue forecast.

Table 8-24 **Annual Farebox Revenue by Corridor**

Corridor	Phase 1	Phase 3
BNSF	$2,479,511	$6,673,695
UP Mainline/Chandler	$1,244,244	$3,348,523
UP Southeast	$3,002,693	$8,088,197
UP Yuma	$1,959,941	$5,273,338

9.0 Evaluation of Alternatives

Minimum thresholds for the operation of high capacity transit systems were identified in Section 3 following the review of several peer group transit systems located throughout North America. These measures have been used to identify a set of criteria to evaluate the potential high capacity transit corridors in order to determine a Recommended High Capacity Transit Network and a plan for phasing the implementation of the corridors. These criteria are:

- Population Density
- Employment Density
- Environmental Justice Population Density
- Boardings per Mile
- Capital Cost per Mile
- Land Use Opportunities
- Right-of-Way Impacts
- Natural Resources Impacts
- Cost Effectiveness

9.1 Population and Employment Data

The population, employment, and environmental justice data collected for each of the corridors is presented in Table 9-1. Population and employment data has been collected using future projections for the MAG region. The ethnicity data used in the environmental justice category is 2002 data since future projections of this information are not available. All data presented has been collected from a one-mile wide (½ mile each side) area around each corridor. The ½ mile distance is accepted as the most common maximum distance a prospective transit rider will walk to access transit station. While some riders would access the corridor from beyond the ½ mile boundary, it is assumed that a substantial majority of system riders would originate from within the ½ mile boundary.

Table 9-1 **Population and Employment Corridor Data**

Corridor	Population Density (per mile)	Total Population	Employment Density (per mile)	Total Employment	Envir. Justice Density	Envir. Justice Pop
59th Ave	5,700	108,292	3,143	59,715	2,856	54,257
Bell Road	5,088	147,546	2,004	58,103	904	25,757
BNSF	4,523	126,651	4,829	135,222	2,262	62,665
Camelback Road	4,610	41,487	6,337	57,033	3,696	77,166
Central Avenue South	7,526	37,629	15,526	77,629	n/a	n/a
Chandler Blvd.	5,643	95,928	3,090	52,538	1,731	28,467
Glendale Avenue	6,795	67,952	3,418	34,176	1,613	31,897
I-10 West	7,137	78,509	11,125	122,371	4,730	52,029
Main Street	8,492	84,915	3,508	35,083	1,762	22,275
Metrocenter/I-17	7,065	63,585	4,466	40,197	4,763	23,814
Power Road	3,481	45,253	3,159	41,063	386	5,015
Scottsdale/UP Tempe Branch	6,063	157,640	6,458	167,914	1,097	30,826
SR-51	4,855	82,541	4,012	68,210	1,807	30,901
UP Chandler Branch	5,126	66,640	4,208	54,707	1,957	21,782
UP Mainline/Chandler	4,957	128,887	7,375	191,741	2,960	76,809
UP Southeast	4,007	144,252	5,516	198,561	1,876	67,868
UP Yuma	2,058	63,811	5,425	168,178	1,287	39,756

9.2 Land Use, Right-of-Way, Natural Resources Opportunities and Impacts

A review of the existing and future land use characteristics in each corridor was preformed to rate the corridors in three categories:

- Opportunities for redevelopment and transit oriented development
- Right-of-Way Impacts
- Impacts to Natural Resources

Table 9-2 summarizes the results from each of these reviews.

Table 9-2 **Summary of Land Use, Right-of-Way, Natural Resources Opportunities and Impacts**

Corridor	Land Use Opportunities	Right-of-Way Impacts	Natural Resources Impacts
59th Avenue	High	Low	Medium
Bell Road	Medium	Medium	Medium
BNSF	High	Low	Low
Camelback Road	High	High	Low
Central Avenue South	Medium	Medium	Low
Chandler Boulevard	Medium	Low	Medium
I-10 West	Medium	Low	Low
Glendale Avenue	Medium	Low	Medium
Main Street	High	Low	Low
Metrocenter/I-17	Medium	High	Low
Power Road	High	Low	Low
Scottsdale Road/UP Tempe Branch	High	Medium	Medium
SR-51	Medium	Medium	Medium
Union Pacific Chandler Branch	High	Low	Medium
Union Pacific Mainline/ Chandler	High	Low	Medium
Union Pacific Southeast	High	Low	Low
Union Pacific Yuma	High	Low	Low

9.3 Cost Effectiveness and Benefit Cost Analysis

Cost effectiveness is a measure used by the Federal Transit Administration (FTA) as part of the Section 5309 "New Starts" program. This program allocates federal capital funding for major transit investment projects. For the purposes of the New Starts evaluation process the cost effectiveness of the project is measured using the following calculation:

(Project annualized capital cost + Project annual operating cost) – (Baseline annualized capital cost + Baseline annual operating cost) / (Total Project Annual Riders – Total Baseline Annual Riders) = Cost Effectiveness

This calculation relies upon a baseline of future transit assumptions and difference between the proposed project and this baseline set of improvements. The corridors and high capacity transit systems here have not been matched to a specific baseline level of transit investment, making it impossible to exactly match the calculation above. Instead, a modified calculation of cost effectiveness has been selected for this portion of the evaluation. This calculation is illustrated below:

(Project Annualized Capital Cost + Project Annual Operating Cost) / Project Annual Boardings = Cost Effectiveness

The annualized figure for capital cost is obtained by multiplying the total project capital cost by 0.08 to annualize the figure over the expected useful life of the improvements. Boardings are annualized by multiplying the weekday boarding figure by an annualization factor of 300. In the case of corridors identified as possibly LRT or Dedicated BRT, the LRT cost-effectiveness figure has been presented. The annualized figure for capital cost is obtained by multiplying the total project capital cost by 0.08 to annualize the figure over the expected useful life of the improvements. Calculations were performed using the New Starts' process for annualizing capital costs to determine the expected useful life differences between commuter rail, LRT, and BRT vehicles. These calculations resulted in annualization factors ranging from 0.078 to 0.083 for the various technologies. This spread of annualization factors results in an insignificant difference in annualized cost and the overall cost effectiveness.

Boardings are annualized for the four commuter rail corridors by multiplying the weekday boarding figure by an annualization factor of 300. The MAG LRT sketch-planning model produces daily boarding figures, which include Saturday and Sunday service. This distinction means that an annualization factor of 365 is more appropriate to accurately annualize the daily LRT boarding figure.

The cost effectiveness figures presented in this report are designed as a tool to compare the corridors under consideration in the High Capacity Transit Study. It would not be appropriate or accurate to compare these figures to other projects such as the CP/EV LRT or other transit projects that have received a certain cost effectiveness rating from the Federal Transit Administration (FTA). This measure differs significantly from the measure used in this study. The High Capacity Transit Study cost effectiveness rating should be used only to evaluate the corridors in this report against each other.

As was the case with the ridership and cost estimates, two rounds of cost effectiveness evaluations were undertaken on the proposed high capacity transit corridors. The figures presented in Table 9-3 represent the refined results from Milestone 5.

Table 9-3 **Cost Effectiveness**

Corridor	Length (miles)	Weekday Boardings	Annual Boardings	Total Cost	Annual Capital Cost	Annual Operating Cost	Cost Effectiveness
I-10 West	11	13,765	5,024,225	$399,343,813	$31,947,505	$10,290,000	$8.41
Union Pacific Chandler Branch	13	12,534	4,574,910	$460,856,044	$36,868,484	$10,440,000	$10.34
Metrocenter/I-17	9	8,848	3,229,520	$337,645,412	$27,011,633	$7,610,000	$10.72
Main	10	9,697	3,539,405	$373,625,175	$29,890,014	$8,960,000	$10.98
Central Avenue South	5	5,749	2,098,385	$228,033,946	$18,242,716	$4,830,000	$11.00
Camelback	9	8,126	2,965,990	$349,356,895	$27,948,552	$7,630,000	$12.00
Scottsdale Rd/Tempe Branch	26	20,672	7,545,280	$1,010,837,127	$80,866,970	$20,950,000	$13.49
Power	13	8,653	3,158,345	$465,103,053	$37,208,244	$8,260,000	$14.40
Chandler Blvd.	17	12,226	4,462,490	$683,750,317	$54,700,025	$9,740,000	$14.44
59th Ave	19	12,829	4,682,585	$727,809,264	$58,224,741	$11,290,000	$14.85
Bell	29	19,750	7,208,750	$1,102,239,771	$88,179,182	$22,550,000	$15.36
UP Yuma	31	12,034	3,610,200	$451,799,232	$36,143,939	$22,400,000	$16.22
Glendale Avenue	10	7,226	2,637,490	$429,215,236	$34,337,219	$8,960,000	$16.42
BNSF	26	16,145	4,843,500	$737,933,062	$59,034,645	$22,550,000	$16.84
SR-51	17	12,334	4,501,910	$823,278,568	$65,862,285	$14,340,000	$17.82
UP Southeast	36	6,198	1,859,400	$567,495,110	$45,399,609	$17,500,000	$33.83
UP Mainline/Chandler	28	4,561	1,368,300	$530,221,490	$42,417,719	$14,250,000	$41.41

Notes: All ridership figures have been obtained from a sketch planning model. All costs are in Year 2001 dollars.

Analysis of Results

The initial cost effectiveness comparisons performed for Milestone 4 resulted in an assessment that commuter rail was not as cost effective as the LRT and Dedicated BRT corridors. The incorporation of the MAG Draft 2 population and employment forecasts and refinements to corridor ridership forecast assumptions resulted in commuter rail service in the BNSF and UP Yuma corridors becoming much more viable when compared to the other recommended corridors. The UP Southeast and UP Mainline/Chandler corridors still face challenges given the anticipated cost of implementing service. In light of these challenges, a recommendation has been made to eliminate the UP Mainline/Chandler corridor from consideration for commuter rail service. Nevertheless, it is recognized that this corridor on the UP Chandler Industrial Branch portion between Chandler and Mesa has a large level of travel demand. Given the results of the cost-effectiveness evaluation performed, it is apparent that this demand would be best served by an LRT/Dedicated BRT corridor paralleling the UP Chandler Branch. Commuter rail demand in the corridor between Mesa and downtown Phoenix would still be served by the UP Southeast corridor. The UP Chandler Branch corridor was specifically reviewed in this analysis and received an excellent cost effectiveness rating (2nd overall). Given this performance by the LRT/Dedicated BRT technology, it is recommended that commuter rail no longer be studied for this corridor.

Despite the lower performance of the UP Southeast corridor compared to the other high capacity transit corridors contained in the recommended network, this corridor remains in consideration for high capacity transit service. This decision has been made considering the regional travel demand in the East Valley and the probable need for fast, long-distance transit service in this portion of the MAG region. Commuter rail is better suited to meeting this demand than are LRT and Dedicated BRT. The UP Southeast corridor faces several cost-related challenges. However, as shown in Section 8, there are alternative operating strategies and technologies that could be implemented to reduce the overall cost of building and operating commuter rail service. These alternatives are promising enough to recommend that commuter rail in the UP Southeast corridor remain in the recommended network of high capacity transit corridors.

At this point in time, this study has a limited ability to produce direct comparisons between LRT and BRT in cost-effectiveness. The MAG Sketch-Planning Model is not capable of distinguishing between LRT and BRT technologies, preventing estimates of the differences in ridership between corridors. However, using the single estimated ridership figures, it is possible to identify specific corridors that would likely perform well with Dedicated BRT service. Corridors with lower ridership figures would be prime candidates for BRT service, because the BRT technology would be capable of providing a comparable level of service at a much lower cost. Given this situation a comparison between the cost-effectiveness figures for LRT and BRT is warranted. Table 9-4 summarizes the cost effectiveness of both transit technologies in various corridors in the MAG region. Additional discussion comparing the capabilities of LRT and BRT is provided in Section 10.

Table 9-4 **LRT-BRT Cost Effectiveness Comparison**

Corridor	LRT Annualized Cost (Capital and O&M) $ millions	BRT Annualized Cost (Capital and O&M) $ millions	LRT Cost Effectiveness	BRT Cost Effectiveness
59th Avenue	$69.51	$40.02	$14.85	$8.55
Bell Road	$110.73	$65.68	$15.36	$9.11
Camelback Road	$35.58	$20.88	$12.00	$7.04
Chandler Boulevard	$64.44	$34.22	$14.44	$7.67
Main Street	$38.85	$28.51	$10.98	$6.23
Power Road	$45.47	$38.85	$14.40	$10.98
Scottsdale Road	$101.82	$27.21	$13.49	$8.61
SR-51	$80.20	$58.23	$17.82	$7.72
Union Pacific Chandler Branch	$47.31	$34.71	$10.34	$7.71

9.4 Benefit Cost Analysis

This section presents the results of the simplified, sketch-planning level benefit cost analysis for 18 corridor-technology scenarios. The benefit-cost analysis results provide the means both to assess the "worth" of each project as well as to rank the projects against each other for purposes of prioritization. The scenarios are listed in Table 9-5.

The 18 scenarios contain all potential LRT corridors. In addition, two representative corridors, Main Street and 59th Avenue, were selected for comparison between LRT and dedicated BRT technologies. These two corridors were selected for the comparison because they are representative of the diverse geographical areas of the valley.

The commuter rail corridors analyzed are the BNSF, UP Yuma and UP Southeast (all Phase 3 service levels). The UP Mainline/Chandler corridor was not included since the cost effectiveness analysis shows its potential ridership could be more effectively served by an LRT/Dedicated BRT corridor.

Table 9-5 **MAG High Capacity Transit Scenarios Evaluated**

Scenario Number	Corridor	Technology
1	Camelback Road	LRT
2	UP Chandler Branch	LRT
3	Main Street	LRT
4	Main Street	Dedicated BRT

Scenario Number	Corridor	Technology
5	Metrocenter/I-17	LRT
6	Glendale Avenue	LRT
7	59th Avenue	LRT
8	59th Avenue	Dedicated BRT
9	Bell Road	LRT
10	Chandler Boulevard	LRT
11	I-10 West	LRT
12	Power Road	LRT
13	Scottsdale/UP Tempe	LRT
14	SR-51	LRT
15	BNSF Phase 3	Commuter Rail
16	UP Yuma - Phase 3	Commuter Rail
17	UP Southeast - Phase 3	Commuter Rail
18	Central Avenue South	LRT

Table 9-6 describes the general categories of benefit included in the benefit-cost analysis. The categories are most easily understood when described in terms of the different groups that benefit from the transit service.

Table 9-6 **Taxonomy of Transit Benefit**

Sources Of Benefit	Recipients Of Benefit		
	Transit Users	**Highway Users**	**Area Communities**
Mobility	Access to employment, day-care, shopping and other destinations for low income people	Greater accessibility to employment and other destinations	Reduced financial burdens on home-based and welfare-to-work social services
Community Livability and Development	Wider range of life-style choice	Time savings in local neighborhoods; more destinations accessible by walk or wheelchair	Greater range of affordable housing; Greater neighborhood diversity and social mix
Sustained Congestion Management in Major Corridors	Sustainable time savings, reliability and predictability in journeys to work and non-work places	Sustainable time savings, reliability and predictability in journeys to work and non-work places	Less pollution and greenhouse gases; Improved Safety; Reduction in sustained outlays on highway infrastructure

Findings

Table 9-7 ranks the 18 scenarios by benefit-cost ratio.

Table 9-7 **MAG High Capacity Transit Project Life Cycle Evaluation Measures (Ranked by Benefit-Cost Ratio)**

Benefit-Cost Rank	Corridor	Technology	Benefit-Cost Ratio
1	UP Yuma - Phase 3	Commuter Rail	4.19
2	I-10 West	LRT	2.64
3	SR-51	LRT	2.28
4	59th Avenue	Dedicated BRT	2.04
5	Metrocenter/I-17	LRT	1.87
6	Bell Road	LRT	1.75
7	BNSF Phase 3	Commuter Rail	1.69
8	Scottsdale/UP Tempe	LRT	1.61
9	59th Avenue	LRT	1.39
10	Camelback Road	LRT	1.31
11	UP Southeast - Phase 3	Commuter Rail	1.30
12	Main Street	Dedicated BRT	1.11
13	Glendale Avenue	LRT	1.05
14	Chandler Boulevard	LRT	0.97
15	UP Chandler Branch	LRT	0.96
16	Main Street	LRT	0.78
17	Power Road	LRT	0.72
18	Central Avenue South	LRT	0.50

Notes: All benefits and costs are in Year 2001 dollars, with a 4% real discount rate

The benefit-cost analysis, like the cost effectiveness calculation, reflects the relationship between ridership and costs within each scenario. However, it is important to recognize that the key additional factor at work in the benefit-cost analysis is the level of roadway congestion forecast for the competing arterial or freeway segment. Transit services competing against roadways that are highly congested will generate high levels of travel time and vehicle operating cost savings. These congestion management benefits constitute a large proportion of the total project benefits in the highest ranked corridors above. Conversely, congestion management benefits from new transit services are lower both in absolute and relative terms in scenarios where roadway congestion will be minor. The results of the benefit-cost analysis could change based on the run of the MAG travel demand model if it is determined that revised congestion levels are markedly different from those assumed in this analysis.

There is considerable variation in results among the scenarios. The benefit-cost ratio ranges from 4.19 in the case of the UP Yuma commuter rail scenario to 0.50 for the Central Avenue South LRT line. Five of the 18 scenarios generate costs in excess of benefits.

As a group, the commuter rail corridors show positive results due in part to the strong ridership forecasts for the West Valley lines. A significant contributing factor is the higher diversion rate from autos that was assumed. In addition, the longer length of the commuter rail corridors compared to the others tends to increase the relative congestion management benefits generated. On the other hand, the commuter corridors exhibit lower benefits in the low income mobility and liveable community categories since a lower percentage of commuter rail riders belong to low income groups.

The strong performance of UP Yuma and the other commuter rail corridors is magnified by the assumed diversion rate of 75 percent from autos compared to 50 percent for LRT and BRT scenarios. As a rule, commuter rail services tend to divert a greater proportion of trips from autos than LRT and BRT services. Commuter rail can be considered a "premium" service compared to the other technologies due to factors such as longer spacing between stations, higher line haul speeds, and more spacious seating. When compared to LRT and BRT, commuter rail often captures a higher proportion of home to work trips occurring during congested peak hours. These are the times of the day when the competitive advantage of transit is greatest.

The primary reason that the UP Yuma scenario generates benefits of such magnitude is the extremely high level of congestion on the competing highway corridor, I-10. In 2040 it is forecast to take more than 6.5 times as long to travel the length of the corridor at peak times than during free flow conditions.

The high level of congestion on I-10 is also the major cause of the high ranking for Scenario 11, I-10 West LRT. High levels of roadway congestion are a significant factor in the high ranking of the SR-51 scenario as well. The results for the UP Yuma, I-10 West, and SR-51 are higher than are typically seen in the consultant team's analyses of similar projects.

The lower relative costs of the BRT scenarios compared to their LRT counterparts cause them to score higher given that ridership is the same for both technologies. This outcome occurs in spite of the smaller community development benefits generated by BRT: the development impact area for BRT encompasses a 0.25-mile radius while a 0.5-mile radius is assumed for LRT. Emissions benefits are significantly lower for BRT as compared to LRT, and in fact both BRT scenarios generate a negative benefit in the emissions category. The one caveat to this result is the expected lower ridership levels that would be generated by a BRT system when compared to an LRT system. This difference in ridership levels would likely result in a reduction in the advantage BRT has over LRT.

9.5 Comparison of Modeling Results

To assist in the evaluation of the Recommended High Capacity Transit Network the MAG four-step transportation model was used to forecast ridership and system utilization for all the corridors contained in the network. Previously, all corridor ridership projections were the result of sketch planning forecasts, which forecasted ridership in each corridor independently. This limitation of the sketch planning model prevented analysis of the entire recommended network operating as a cohesive unit.

Four-stage modeling and sketch planning modeling methods each have positive attributes and limitations in terms of assessing high capacity transit services. Because of these varying attributes and limitations, it was agreed between MAG and project consultant that both modeling methods should employed during the development of the High Capacity Transit Study in order to perform appropriate analysis on the recommended corridors. The ridership forecasts presented earlier in Section 8 are the result of the sketch planning modeling approach. This method determines transit trips based on trip rates for population and employment, using catchment areas within distance bands of transit stops. Attempting to develop accurate mode splits using four-stage modelling can be difficult for modes with low shares, and the direct demand (sketch planning) approach avoids this difficulty by combining the trip generation and mode split steps. The MAG four-stage model run allowed for the opportunity to observe how each of the proposed corridors operates as part of a larger network of corridors, creating linkages between corridors and illustrating the influences of complementary and completing corridors. While not intended to supersede the sketch-planning projections, this additional analysis provides additional detail and perhaps indicates whether the network effects are positive or negative for individual corridors.

Comparison of the Results

Overall, the MAG model forecasts around a third more riders than the sketch planning methodology. However, two corridors - Bell Road and the BNSF commuter rail line - can explain over 80 percent of this discrepancy. There are technical reasons for the high MAG model ridership along these corridors, and these are explained below. If these two corridors are removed, overall ridership is only 7 percent above the sketch planning results. Table 9-8 below compares each corridor in turn.

Table 9-8 **Comparison of MAG Model and Sketch Planning Results by Line**

Corridor	MAG Model Forecast	Sketch Plan Forecast	Difference
59th Ave	14,290	12,829	11%
Bell Rd	57,680	19,750	192%
Chandler Boulevard	5,201	12,226	-57%
UP Chandler	5,666	12,534	-55%
I-10 West	4,871	13,765	-65%
Power Rd	2,484	8,653	-71%
Scottsdale Rd	27,727	20,672	34%
SR-51	10,204	12,334	-17%
BNSF	28,227	8,073	250%
UP SE	9,594	3,099	209%

Corridor	MAG Model Forecast	Sketch Plan Forecast	Difference
UP Yuma	16,163	6,017	169%
Glendale/Camelback	21,848	15,352	42%
Central Ave	2,965	5,749	-48%
Mesa Rd/Metro Center	87,610	71,039	23%
TOTAL	**294,530**	**222,089**	**32.6%**

MAG model projections for the other two commuter rail lines are also higher than sketch planning projections, particularly for UP Yuma. On the other hand, projections for some of the lines in the south east of the MAG region are lower.

It should be noted that all LRT/Dedicated BRT corridors were run as LRT corridors in order to analyze the corridors on an equal footing terms of operations and system configuration. Specific technologies for each corridor would be determined in subsequent Major Investment Studies (MIS) performed in each corridor. Observations on recommended transit technologies are included in Section 10.

West Valley Growth

The largest discrepancies between the MAG model and the sketch-planning model occur for the BNSF commuter rail corridor and the Bell Road BRT/LRT line. It is believed that the very high ridership predicted by the MAG model for these corridors is overstated, due to unrealistic congestion on the roads in the area. Congestion is a network effect not included in the sketch-planning model.

A high rate of both population and employment growth has been projected for the West Valley. For instance, between 2000 and 2040 the population of Surprise is forecast to increase over 17 times above its current level. This represents an increase from 1.2 percent to almost 9 percent of the MAG region's population. Employment growth for the city is even greater, projected to increase almost 22-fold increasing the proportion of the region's jobs from 0.6 percent to 5.1 percent by 2040. This growth in population and employment leads to very large increases in trips made to and from the West Valley.

However, neither the base transit network, nor the base highway network, keeps pace with this growth in trips. The result is severe congestion on the only major roads in the area, with a consequent drop in level of service. For instance, speeds in places on Grand Ave and Bell Road in the AM peak drop as low as 1mph and 2mph respectively. These low speeds lead to extended auto journey times and hence make transit a very attractive alternative, overstating mode shares. In reality, should congestion reach such high levels the overall number of trips would actually be suppressed, but with the fixed matrix trips continue to be made - leading to very high transit ridership.

Exhibit 9-1 **Projected Year 2040 Transit Trips Including High Capacity Transit Network**

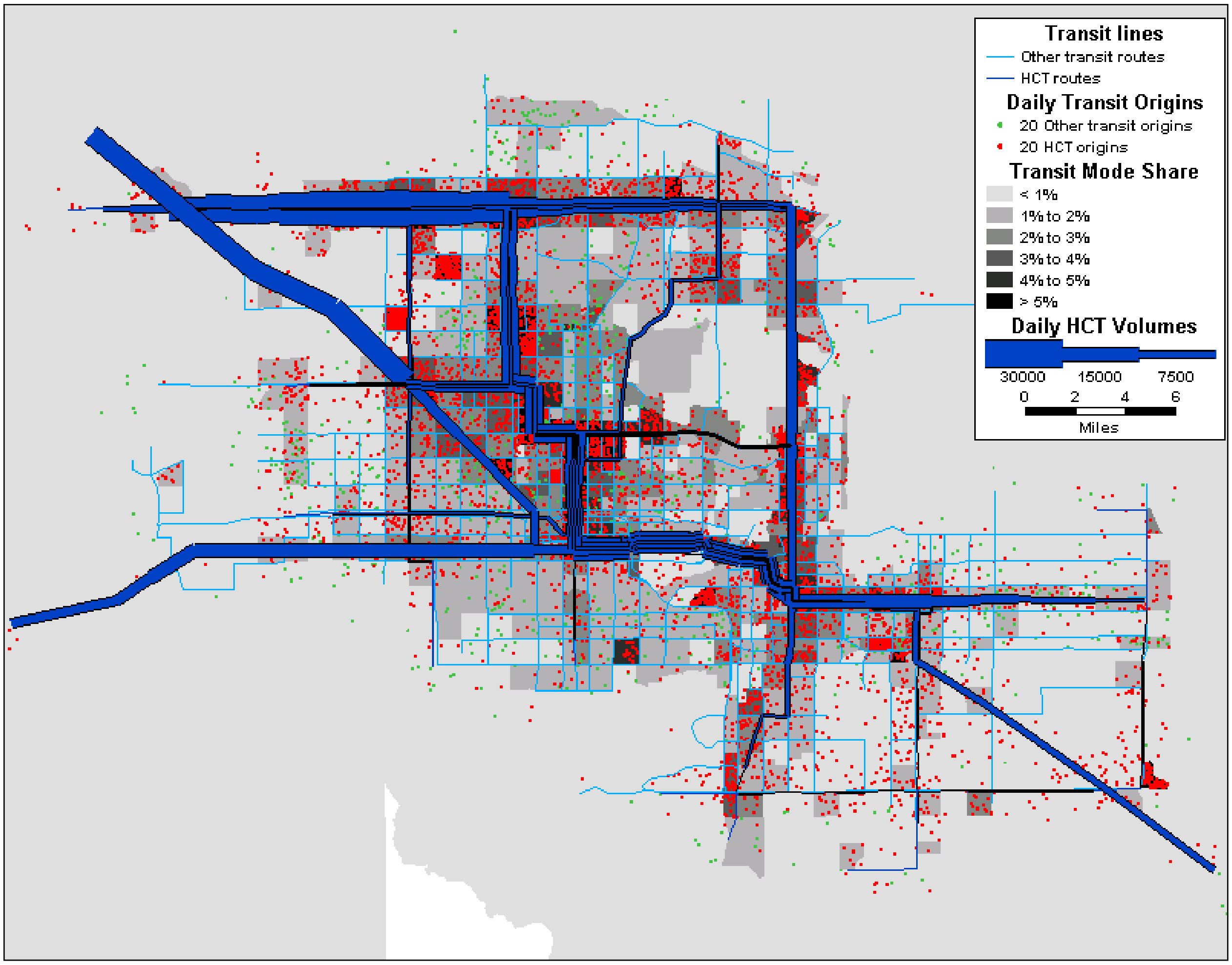


Exhibit 9-1 illustrates the high capacity transit ridership, and the origin of transit trips. While ridership on the BNSF and Bell Road is highest in the northwest, there are few origins to the northwest of these stations. It appears that congestion is so severe that trips are actually made in the outbound direction in the AM (i.e. against the peak) or around Loop 303 to avoid congestion, causing the vast majority of boardings to occur at these stations.

Rapid growth in population and employment also occur in the southwest (i.e. UP Yuma corridor), leading to congestion in this area and hence perhaps a slight overstatement of ridership. However, congestion in this corridor does not appear to be as severe as that in the northwest, and this may be due to the presence of the I-10 freeway. This facility has more capacity than the lower standard roads in the northwest such as Bell Road and Grand Avenue.

While the unrealistic levels of congestion suggest we cannot use the MAG model projections for the Bell Road LRT/BRT and BNSF commuter rail directly, they do confirm that these are nonetheless strong corridors with good growth potential. They indicate that the sketch planning forecasts are on the conservative side and future congestion in this area may lead to some upside.

Complementary Corridors

A second network effect not included in the sketch planning approach is the increased ridership that the connectivity of a network can provide. If interchanges are smooth, with short wait times, the effective corridor serves not just the immediate catchment area, but rather all areas of the MAG Region in the catchment area of any high capacity transit corridor. The MAG model includes this effect, and the impact is most obvious for the longer corridors, which may provide the most interchange opportunities. Time benefits are also not explicitly included in the sketch-planning model. As these increase with corridor length, this may be another reason why the longer corridors tend to have higher ridership projections relative to the sketch planning approach.

Projections from the MAG model for Scottsdale Road projections are over a third higher, showing the effect of good connections with Bell Road, Camelback Road, and Central Phoenix/East Valley LRT corridors. Glendale and Camelback are combined into one service in the MAG model projections. The creation of a through-running corridor across the central portion of the MAG region, as well as other connectivity, helps to increase the projections in these corridors by 42 percent relative to those from the sketch planning approach. It should be noted that some of these extra riders are probably due to overstated transit trips from the northwest.

Perhaps the strongest example of the network connectivity benefits is the Metrocenter/I-17-CP/EV-Main Street corridor. This extended route is the spine of the high capacity transit network and, therefore, it has the most opportunities for interchange with other corridors. While a small part of the 28 percent increase in ridership from the sketch planning projections may be due to congestion from the northwest valley, these results mostly illustrates the strategic benefit of a transit network rather than a single corridor.

The ability to interchange between corridors is not represented in sketch plan model, so it is intuitive that projections for these corridors are higher. Overall, where connectivity rather than competition is the main network effect, ridership is around 25 percent higher than the sketch planning results. Although some of this increase may be due to northwest congestion concerns, the MAG model confirms the strength of these corridors, the effects of connectivity, and suggests an increased likelihood of upside compared to downside.

Competing Corridors

Where two corridors serve similar origins and destinations, they may compete for transit riders. This third network effect is not included in the sketch-planning model. In this case, MAG model can indicate where competition may occur, and the impact this competition may have upon ridership projections.

The most obvious example of the competition effect is the interaction between the UP Yuma commuter rail corridor and the I-10 West LRT corridor. MAG model projections for UP Yuma are 169 percent higher than the sketch planning projections, while I-10 West projections are 65 percent lower. However, by combining the two corridors MAG projections are only 6 percent higher. These results suggest that trips in the I-10 corridor are instead using the UP Yuma commuter line, for reasons discussed below.

There may be a similar competition effect in the East Valley, where MAG projected ridership for many of the LRT/BRT corridors is substantially lower than projected by the sketch planning approach, while ridership for UPSE commuter rail and the Main Street LRT corridor are higher. Combining all the corridors of the East Valley (UPSE, UP Chandler, Power Road, Chandler Boulevard, and Mesa-I-17/Metrocenter LRT) gives MAG model ridership figures only 1% higher than from the sketch planning approach. While the Main Street corridor also includes trips on the Metrocenter/I-17 and CP/EV sections, it could be argued passengers are accessing this section from the Main Street section directly in the MAG model, rather than by interchanging from other East Valley corridors.

It would therefore appear that it is the distribution of trips between competing corridors rather than overall totals that are most different. One reason for this may be due to the access methods represented. The sketch planning approach assumes that there is strong provision of feeder services to the high capacity transit network. However, the MAG model network does not include these feeder networks, merely superimposing the HCT network on the existing transit network. Instead, much of the HCT network is accessed by car – almost 80 percent of trips are made this way, more than double the proportion observed in other LRT systems in Southwest United States[1].

Park-and-ride tends to favor commuter rail, which has higher line-haul speeds and fewer stops, so this may lead to the MAG model projecting higher mode shares for commuter rail where it competes with LRT/BRT. Congestion may be encouraging park and ride trips to use the outer UP Yuma line stations rather than the I-10 West stations. This would probably have been more likely based on the transit trip origins. Road congestion is less of a problem in the East Valley, although there does appear to be evidence of some trips being made outbound to Queen Creek. For most

[1] Source: Parsons Brinkerhoff Quade & Douglas, Inc 1999, Phoenix Model Development Project

areas, park-and-ride and kiss-and-ride trips are not forced to the nearest station, but to the corridor with the shortest line-haul times and with the fewest interchanges. With feeder services, it may be more convenient for many of these trips to access a nearer LRT/BRT corridor and make more interchanges.

The representation of commuter rail in the MAG model may also lead to an overstatement of its mode share relative to LRT. As commuter rail is a new mode, the mode choice sub-model cannot be calibrated explicitly, and instead it is represented as a high-speed LRT with limited stops. In reality, however, commuter rail station access is generally less convenient than LRT, which would tend to depress demand. The LRT corridor emphasis on 'turn up and go' also leads to them attracting higher demand than commuter rail corridors where journey times are similar.

Table 9-9 provides a context for the MAG model commuter rail forecasts in a comparison with existing systems. The boardings per mile comparison suggests that the MAG model projections are out of line with other systems in the Southwest United States systems, and could only be attained with urban development at least as dense as Toronto, Canada. On the other hand, the peer comparison confirms the sketch planning forecasts are in line, if a little higher due to the distant timescale the forecasts represent.

Table 9-9 **Comparison of Commuter Rail Forecasts with Existing Systems**

Line	Distance (miles)	Boardings	Boardings per Mile
Observed Peer Transit Systems			
Los Angeles Metrolink IE-OC	59	3,003	51
San Diego Coaster	43	5,000	116
Dallas Trinity Railway Express	37	5,900	159
San Jose Altamont Commuter Express	82	3,300	40
Toronto Go Transit Lakeshore East	42	40,715	969
Chicago NICTD Southshore Line	90	12,800	142
MAG Model Forecasts			
BNSF	28	28,227	1,018
UP Yuma	33	16,163	497
UP Southeast	36	9,594	265
Sketch Plan Forecasts			
BNSF	28	8073	291
UP Yuma	33	6017	185
UP Southeast	36	3099	86

While this may suggest that MAG model projections for the commuter rail lines may be overstated at the expense of understated BRT/LRT line projections, it does perhaps indicate the most likely direction actual ridership may diverge from the forecasts. There may be potential for some downside with the BRT/LRT corridors in the East valley - particularly for Power Road - while UP SE and the Main Street LRT corridor have potential for upside.

Other Corridors

Projections for 59th Avenue and SR-51 corridors are similar between the MAG model and sketch plan approach, and show overall compatibility between the two sets of results. MAG model projections for Central Avenue are somewhat lower however, and it is believed that this illustrates another aspect of competition between transit lines.

The MAG model includes an existing bus service operating along Central Avenue with a headway of 12 minutes, similar to the high capacity transit headway of 10 minutes. As this also continues north of downtown Phoenix, it is attractive to transit riders despite its lower speed. Assuming the existing service would be truncated following the introduction of the high capacity transit service, passengers boarding the existing service can be included in the high capacity transit ridership where it operates the same route. This increases the MAG model projections for the Central Avenue South LRT to 5,140, only 11 percent below the sketch planning forecasts.

Table 9-10 below combines the corridors into the groups defined above.

Table 9-10 **Comparison of Modeling Results by Corridor Group**

Corridor Group	MAG Model Forecast	Sketch Plan Forecast	Difference
BNSF/Bell Road	85,907	27,823	209%
Increased Connectivity	137,185	107,063	28%
UPYuma/I-10 West	21,034	19,783	6%
East Valley[2]	110,555	109,004	1%
Other[3]	29,634	30,912	-4%
TOTAL (Adjusted)[4]	210,798	195,722	8%

This grouping shows that while comparisons on a line-by line basis initially suggest large differences between the modeling approaches, overall differences are much smaller. The largest difference is due to the congestion problems of the northwest, but that aside the largest impact appears to be the network effects of connectivity, slightly increasing overall ridership.

Calculated from such small mode shares, the MAG model projections should be treated with caution at a detailed level. For the northwest sector,

[2] Includes Metro Center and CP/EV
[3] Includes Central Avenue existing bus service.
[4] Includes Central Avenue existing bus service but does not include BNSF or Bell Road. Forecasts do not add up to total as Metro Center-CP/EV-Main Street corridor is included in both “East Valley” and “Increased connectivity” categories

even the order of magnitude can only be determined from the sketch planning results. However, they can indicate whether a corridor has more potential for upside or downside, and also provide some useful additions to the network-insensitive sketch planning approach.

Finally, as a regional model, the MAG model can provide context for the corridor projections. It shows the continuing dominance of the car in the MAG region, with overall transit mode share at only 1.2 percent even with the development of a network of high capacity transit corridors. However, if we consider that more than a third of high capacity transit ridership is from zones with transit mode share above 5 percent, even discounting the problems of the northwest sector the MAG model suggests that where high capacity transit service is provided a reasonable mode share for transit can be achieved.

10.0 Recommended High Capacity Transit Network

The previous sections of this report present data on forecasted population, employment, ridership, cost, and cost effectiveness for the potential high capacity transit corridors. The evaluation process undertaken to analyze these corridors was a two-step process. The initial round of evaluations occurred in Milestone 4 and included a full evaluation of 28 corridors located throughout the MAG region. This initial evaluation resulted in the screening out of several corridors including all seven proposed Express BRT corridors, and originally, the Baseline Road corridor. As noted above, the UP Mainline/Chandler commuter rail corridor was screened out in the refined evaluation as a result of cost effectiveness.

During the course of the Milestone 6 review process, further consideration was given to the underlying factors surrounding future high capacity transit demand in south Phoenix. In particular, the Baseline corridor is a major arterial street that spans almost the entire metropolitan area from east-west, making this street an important regional corridor similar to Bell Road or Camelback Road.

From this review, it became apparent that the absence of a fully developed local and arterial street network along the Baseline corridor, and in the segment west of South Central Avenue in particular, could result in some potentially understated ridership forecasts in an area which has already has demonstrably strong demand for local transit.

With this degree of ambiguity in the transit demand forecasts for this specific area, it makes sense to retain the corridor for further consideration when a more robust picture is provided of the local street network, population and employment forecasts, all of which will only be available beyond the duration of this Study.

The Baseline corridor's mobility characteristics and the Study's demand conclusions suggest that several of the parallel east-west corridors would merit inclusion in a further analysis of Baseline to assess the suitability of high capacity transit service. Such analysis should extend at a minimum to the Broadway, Southern and Baseline arterials.

A summary of the data collected for the corridors contained in the Recommended High Capacity Transit Network is presented in Table 10-2. This table also includes a rating system to allow for a comparison of each of the corridors in a particular category. These ratings have been used to identify preliminary recommendations for corridor phasing. The results of the phasing recommendations are presented in Section 11.

The ratings assigned the individual corridors represent how positive the evaluation result is in comparison to the capability of the corridor to support high capacity transit service. The ratings and their general meanings are presented below:

- = Very Supportive
- = Supportive
- = Neutral
- = Not Supportive
- = Significant Constraint

Table 10-1 presents the rating applied to a range of values under each evaluation criteria. The evaluation results are summarized in Table 10-2 on the following page.

Table 10-1 **Evaluation Criteria Rating Assignments**

Criteria	Significant Constraint	Not Supportive	Neutral	Supportive	Very Supportive
Population Density (sqmi)	0 – 2,000	2,001 – 4,000	4001 – 6,000	6,001- 8,000	8,001 – 10,000
Employment Density (sqmi)	0 – 2,000	2,001 – 4,000	4,001 – 6,000	6,001 – 8,000	8,001 – 10,000 (& over)
Environmental Justice Density	0 – 1,000	1,001 -2,000	2,001 – 3,000	3,001 – 4,000	4,001 – 5,000
Boardings per Mile	0 – 300	301 – 600	601 – 900	901 – 1,200	1,201 – 1,500
Capital Cost per Mile ($ millions)	$50 - $40	$40 - $30	$30 - $20	$20 - $10	$10 - $0
Land Use Opportunities	n/a	Low	Medium	High	n/a
Right-of-Way Impacts	n/a	High	Medium	Low	n/a
Natural Resources Impacts	n/a	High	Medium	Low	n/a
Cost Effectiveness	$50.00 – $40.01	$40.00 – $30.01	$30.00 - $20.01	$22.00 - $10.01	$10.00 - $0.00
Benefit Cost	0.00 – 1.00	1.01 – 2.00	2.01 – 3.00	3.01 – 4.00	4.01 – 5.00

Refinements have been made to the threshold levels in the evaluation criteria between the High Capacity Transit Plan Milestone 4 Report and the Final Report. These refinements were made primarily in response to the incorporation of the MAG Draft 2 population and employment projections. These projections changed the employment and population density levels on all corridors included in the evaluation.

The corridors evaluated above were selected using the results of the peer group review of existing transit systems conducted in Milestone 2. One outcome of this peer review was the identification of minimum levels of population and employment densities present for each of the existing systems. These observations were meant to serve as a guide for identifying corridors in the MAG region that could be capable of supporting some form of high capacity transit. The corridors contained in the evaluation table above all meet these minimum threshold levels.

The main objective of the evaluation was to compare the corridors to *each other*, using common criteria that would produce results for each corridor. In order to conduct a fair review, the criteria thresholds for each level (1-5) was set out on an equal interval, with the overall range encompassing the values assigned to each corridor. These criteria thresholds were modified in light of the new Draft 2 population and employment figures in order to provide a more accurate forecast of how the corridors compared to each other not to outside thresholds.

Table 10-2 Evaluation Results

Corridor	Length (miles)	Population Density (per mile)	Employment Density (per mile)	Envir. Justice Density (per mile)	Boardings per Mile	Capital Cost per Mile	Land Use	Right-of-Way	Natural Resources	Cost Effectiveness*	Benefit Cost
59th Avenue	19	5,700	3,143	2,856	675	$38.31				$14.85	1.39
		◑	◔	◑	◑	◔	◕	◕	◑	◕	◔
Bell Road	29	5,088	2,004	904	681	$38.01				$15.36	1.75
		◑	◔	○	◑	◔	◑	◑	◑	◕	◔
BNSF	28	4,523	4,829	2,262	287	$26.35				$16.84	1.69
		◑	◑	◑	○	◑	◕	◕	◕	◑	◔
Camelback Road	9	4,610	6,337	3,696	903	$38.82				$12.00	1.31
		◑	◕	◕	◕	◔	◕	◔	◕	◕	◔
Central Avenue South	5	7,526	15,526	n/a	1,150	$45.61				$11.00	0.50
		◕	●		◕	○	◑	◕	◕	◕	○
Chandler Boulevard	17	5,643	3,090	1,731	719	$40.22				$14.44	0.97
		◑	◔	◔	◑	○	◑	◕	◑	◕	○
Union Pacific Chandler Branch	13	5,126	4,208	1,957	964	$35.45				$10.34	0.96
		◑	◑	◔	◕	◔	◕	◕	◑	●	○
Glendale Avenue	10	6,795	3,418	1,613	723	$42.92				$16.42	1.05
		◕	◔	◔	◑	○	◔	◕	◑	◕	◔
I-10 W	11	7,137	11,125	4,730	1,251	$36.30				$8.41	2.64
		◕	●	●	●	◔	◑	◕	◕	◕	◑
Main Street	10	8,492	3,508	1,762	970	$37.36				$10.98	0.78
		●	◔	◔	◕	◔	◕	◕	◕	◕	○
Metrocenter/I-17	9	7,065	4,466	4,763	983	$37.52				$10.72	1.87
		◕	◑	●	◕	◔	◑	◔	◕	◕	◔
Power Road	13	3,481	3,159	386	666	$35.78				$14.40	0.72
		◔	◔	○	◑	◔	◕	◕	◕	◕	○
Scottsdale Road/UP Tempe Branch	26	6,063	6,458	1,097	795	$38.88				$13.49	1.61
		◕	◕	◔	◑	◔	◕	◑	◑	◕	◔
SR-51	17	4,855	4,012	1,807	726	$48.43				$17.82	2.28
		◑	◑	◔	◑	○	◑	◑	◑	◑	◑
Union Pacific Mainline/Chandler	26	4,957	7,375	2,960	175	$20.39				$41.41	n/a
		◑	◕	◑	○	◑	◕	◕	◑	○	n/a
Union Pacific Southeast	36	4,007	5,516	1,876	172	$15.76				$33.83	1.30
		◑	◑	◔	○	◕	◕	◕	◕	◑	◔
Union Pacific Yuma	31	2,058	5,425	1,287	388	$14.57				$16.22	4.19
		◔	◑	◔	◔	◕	◕	◕	◕	◑	●

Note: No Environmental Justice figures were obtained for Central Avenue South. Population and employment forecasts are for Year 2040. Environmental Justice is actuall 2002 figures.

The overall objective of the Recommended High Capacity Transit Network is the creation of an integrated system of high capacity transit corridors providing efficient and convenient travel throughout the MAG region. An important part of these corridors fulfilling their objective is to ensure that there are connections between the corridors and that these connections facilitate the movement of riders between systems no matter which transit technology is being operated. Exhibit 10-2 illustrates the Recommended High Capacity Transit Network. The likely connection points between each corridor and intersecting corridors are illustrated in this map along with the connections made to the assumed base high capacity transit corridors such as the CP/EV LRT and the Phoenix Rapid Bus system.


RECOMMENDED HIGH CAPACITY TRANSIT NETWORK
Legend
Station
Connection
Commuter Rail
CP/EV LRT
Existing Express BRT
LRT/Dedicated BRT
Proposed Express BRT
Freeway
Proposed Freeway/Parkway/Highway
Major Arterials
0 1.25 2.5 5 7.5 10 Miles
N
W
E
S
DRAFT: December 31, 2002
Surprise
ElMirage
Peoria
Tolleson
Goodyear
Buckeye
Bell Road
Glendale Avenue
59th Avenue
W. Phoenix Glendale
I-10 West
West Phoenix
Metro Center
Central Avenue South
Downtown Phoenix
Sky Harbor
SR-51
Camelback Road
Scottsdale Road
Downtown Tempe
East Tempe
Main Street
Mesa
Gilbert
Power Road
Williams Gateway
Chandler Boulevard
UP Chandler Branch
UP Tempe Branch
Queen Creek
17
101
303
10
51
202
60

10.1 High Capacity Transit and the Developing Valley Metro Network

High capacity transit services will effectively replace some local bus services, but much of Valley Metro's growing grid system will remain intact. Even with high capacity transit services in operation, fixed route and shuttle bus services will continue to provide important local circulation in many of Maricopa County's communities, as well as some regional BRT Express services on freeways, utilizing park-and-ride lots and HOV lanes.

A separate ongoing project, the Valley Metro Regional Transit System Study, is identifying the local and express bus network for Maricopa County for 2025. That study is modeling transit demand based on changes in population growth, land use and densities over the next 25 years. The focus of the study it to identify the need for bus transit services based on density and transit dependence. The transit-dependent market — a significant component of the analysis as part of the Regional Transit System Study — is one of many markets that would be served by a high capacity transit system. The methodology for assigning services as part of the Regional Transit System Study was similar to the effort undertaken for the High Capacity Transit Study, but with one key difference: the High Capacity Transit Study has a limited number of corridors where services can be implemented, and corridors cannot be defined as narrowly as they are in the Regional Transit System Study.

All of the alternatives for LRT/BRT operate in the higher density corridors that have been targeted by Regional Transit System Study planners for fixed route and commuter connection bus service. For example, the Camelback Road corridor has been identified by high capacity transit planners as an important corridor for BRT/LRT, particularly since Camelback Road congestion is projected to increase by 30% between now and 2040. Employment density along this corridor is among the highest in the region, and population density is also strong. This mix of high employment and population density contributes to making this an attractive corridor for high capacity services, but the mix of land uses also suggests a high number of local trips may be better served by the fixed route bus system.

11.0 Implementation Plan

An important component in developing a recommended high capacity transit network is determining when and how the corridors should be implemented. Proper phasing of projects is essential to ensure that growing ridership demands are met and that improvements are scaled to funding levels available. Included here is a brief overview of phased implementation of transit services, why it is done, a recommended prioritization of the corridors, a discussion about technology selection, and an action plan detailing the next steps in moving closer to corridor implementation.

The levels of service described for each of the commuter rail, LRT, and Dedicated BRT corridors in this report represent the *ultimate level of service* that each transit technology must provide to accommodate the ultimate estimated ridership demand in the various corridors. This ultimate level of service would be achieved at full development of the system. In reality, the development of service would be implemented in phases over a period of years, as underlying population and employment growth drives new ridership. Several criteria are involved in determining the phasing-in of new high capacity transit service. These criteria are essentially similar from technology to technology; however, there are distinctive differences. A general overview of why phasing is a preferred option for implementing high capacity transit along with a description of phasing steps for each technology are presented below.

Commuter Rail

As described in the ridership and cost estimates, this report has explored three major phasing steps for implementing commuter rail service. Each phase represents a dramatic improvement in service above the previous level of service. There are several ways of transitioning between levels of service. This transition can be done incrementally with only a single roundtrip train added each year, or improvements can be implemented through a larger change from one phase to the next. The driving factors behind the pace of implementing later phases of commuter rail will be funding availability and ridership growth. The three major phases of commuter rail implementation are described below:

Start-up Phase – Peak period service only, consisting of two or three trains inbound during the morning peak and outbound in the evening peak.

Intermediate Phase – Additional peak period service in peak direction is provided. Midday service and reverse commute service in the peak period are also implemented.

Ultimate Phase – The maximum amount of commuter rail service that a corridor can support. Very frequent peak service in both directions and expanded off-peak service with a span of service of 15 to 19 hours daily.

Light Rail

Light rail is a very different technology from commuter rail in terms of its operating characteristics. LRT systems are designed to provide frequent, all-day service from the first day of implementation, unlike commuter rail which can be a viable service with only two to three trains operating each day. A primary reason for this initial implementation of frequent service is the large amount of capital investment required to implement LRT.

Phasing in of LRT service would primarily consist of gradual shortening of headways and increased spans of service. Many LRT systems will open with 10 to 15 minute headways during peak periods and 20 to 25 minutes in off-peak times. As ridership levels grow headways would be shortened to five minutes or less during peak times and 10 minutes or less during off-peak.

Bus Rapid Transit

BRT technology is similar to commuter rail in that the phasing of service is very flexible, and can be implemented of a series of small stages over time to allow for funding availability and ridership growth. The lower infrastructure requirements for BRT allow for minimal levels of investment to begin a basic service and the flexibility of BRT vehicles allows for a staged implementation over many years.

The first phase of BRT service is typically the implementation of a “rapid” or limited stop bus service with signal priority and special vehicles and stations. Because of the flexibility of this phase of BRT service and the overall limited capital investment required, rapid bus could also be used as an initial phase building up the implementation of an LRT system. Once the LRT service is in place the buses used to operate rapid bus service could be reassigned to other corridors.

Bus lanes represent the next phase in implementing BRT service. These lanes are usually located on the curb side of an arterial street and can either be exclusive or allow for some vehicle traffic during off-peak times or at intersections for turning movements.

Exclusive bus lanes separated from vehicle traffic either in the street median or an exclusive right-of-way such as a former freight railroad corridor represents the ultimate phase of BRT service. This service requires the greatest level of capital investment, but is capable of providing faster service than other forms of BRT as a result of the exclusivity of operations from cross traffic interference.

11.1 Phasing and Prioritization

Overall phasing of service may result in the total long term capital cost of implementing transit service to be higher than if the service was implemented at full capacity immediately. However, the latter approach is not usually realistic given the cost investment required to implement a full service transit system. Similar to the development of a freeway network when a six lane freeway is widened to eight lanes to meet growing demand, improvements are done to transit systems in phases to match growing ridership demand. This spreads the cost burden over several years or possibly decades allowing for benefits to be provided at an earlier stage than if construction was delayed until the full system could be implemented.

The High Capacity Transit Study is designed to be the first step in developing and prioritizing the recommended network of high capacity transit services in the MAG region. This prioritization will continue at a more detailed level during the development of the MAG Regional Transportation Plan (RTP). One of the main objectives of the RTP will be to set out a specific prioritization of the transit corridors identified in the recommended network using additional analysis of population and employment projections, an estimation of expected funding availability, and extensive public consultation.

The 16 corridors contained in the Recommended High Capacity Transit Network have been categorized into three groups for the purposes of prioritization. The key considerations in setting forth the prioritization recommendations for the High Capacity Transit network are both quantitative and qualitative. They include:

- Analysis of expected population growth levels and anticipated timing of this future growth: the study scope approaches the potential demand for the high capacity transit system at full build-out of population and employment for the MAG region. However there are major differences in the rates at which this growth will generate appropriate thresholds of ridership across the region and within the corridors. The study has undertaken a review of the latest DRAFT2 socioeconomic forecasts at Traffic Analysis Zone levels to assess the likely build up of ridership to targeted 2040 levels.
- Estimated ridership.
- Linkages to the committed network of high capacity transit: the high capacity transit network is intended to enhance regional mobility. As such, connectivity with other elements of the network, including those which are natural extensions of the LRT and BRT networks which are already funded (CP/EV LRT, Central Avenue/Phoenix BRT corridors) are a key consideration in identifying early gains from high capacity transit development.
- The cohesiveness of the overall network, ensuring that future corridors link to previously implemented corridors.

The three groups of corridors identified here have been classified as the Short-Term, Middle-Term, and Long-Term Implementation corridors. Assuming a 40 year horizon for the population and employment projections used in this report, the Short-Term corridors would likely be recommended for implementation during the next 15 years, while the Middle-Term corridors would be implemented within a 15-30 year time frame. The Long-Term corridors would complete the high capacity transit network during the final ten years of the study period (2030 to 2040). It is essential to note that these classifications are not permanent. They are designed as a guide for future refinement as part of the RTP process. Changes in population growth levels, timing, and the location of future growth would result in changes to the corridors contained in each level.

11.2 Implementation of Corridors

The first set of corridors have been placed into the Short-Term Implementation category for several reasons including their performance in the cost effectiveness and Benefit Cost analysis, the objective of creating an integrated regional high capacity transit network resulting from the connections these corridors provide to the planned CP/EV LRT, and the objective of bringing some form of high capacity transit service to as many areas of the MAG region as possible during the first half of the planning horizon period. These criteria and objectives have resulted in the following recommendations for the Short-Term Implementation corridors:

- Camelback Road
- Glendale Avenue
- I-10 West
- Main Street
- Metrocenter/I-17
- Scottsdale Road/UP Tempe Branch (Downtown Scottsdale to CP/EV LRT)
- SR-51 (Central Avenue to Cactus Avenue)
- Commuter Rail corridors – begin negotiations with freight operators and MIS work.

The Medium-Term corridors are:

- 59th Avenue (Glendale Avenue to I-10 West)
- Bell Road (Scottsdale Road to 59th Avenue)
- BNSF (Start-up Phase)
- Central Avenue South
- Scottsdale Road/UP Tempe Branch (North of Downtown Scottsdale and South of CP/EV LRT)
- SR-51 (Cactus Avenue to Loop 101)
- UP Chandler Branch

- UP Southeast (Start-up with reverse commute to Williams Gateway)
- UP Yuma (Start-up)

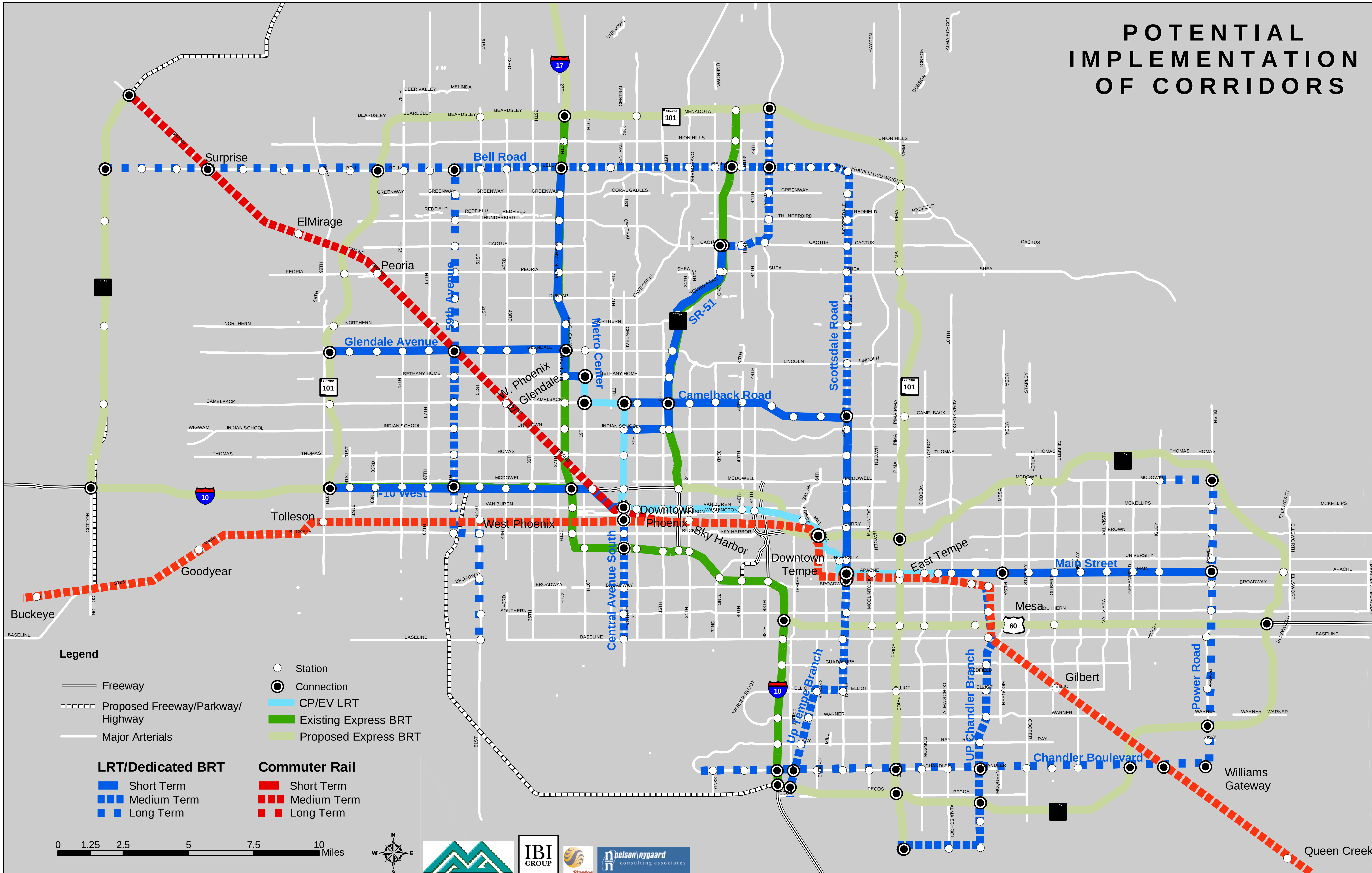
The Long-Term corridors are classified as such because of the timing of future growth during the outlying years of the study horizon. Earlier implementation of these corridors would not be cost effective due to the lower ridership base that would be available. The corridors are:

- 59th Avenue (Bell Road to Glendale Avenue and I-10 West to Baseline Road)
- Bell Road (59th Avenue to Loop 303)
- BNSF (Ultimate to Loop 303)
- Chandler Boulevard
- Power Road
- UP Southeast (Ultimate)
- UP Yuma (Ultimate)

There are recommendations for phased implementation of several of the corridors listed above. The characteristics of these phased implementations are described above. Specifically, the commuter rail corridors will require phased implementation and a period of time in which to build ridership and upgrade the existing rail infrastructure. The Scottsdale Road/UP Tempe Branch corridor is recommended for implementation in two phases as a result of the higher existing congestion and density between downtown Scottsdale and the planned CP/EV alignment. Growth in portions of this corridor to the north and south of these limits occurs further out in the future, allowing for some delay in implementing service.

While the implementation of commuter rail service has been identified for the medium term (15-30 years) period, it is recommended that work proceed in the short-term to advance the definition of how and where commuter rail service would be provided to the MAG region. Negotiations with freight rail operators and the development of a regional commuter rail governing and administrative organization is a time-consuming process that could take several years. These efforts should begin in the short-term period in order to allow for future engineering work. Major investment studies (MIS) should also be prepared in corridors during the next 15 years to identify demand for service and service operating characteristics. Early completion of MIS work will allow for flexible implementation of commuter rail service either prior to the medium term time frame should growth outpace projections or later in the 15-30 time period if growth does not occur as forecast in a specific corridor.

Exhibit 10-1 illustrates proposed implementation timeline for the Recommended High Capacity Transit Network.



POTENTIAL IMPLEMENTATION OF CORRIDORS
Surprise
ElMirage
Peoria
Bell Road
59th Avenue
Glendale Avenue
W. Phoenix Glendale
Metro Center
SR-51
Scottsdale Road
Camelback Road
I-10 West
Tolleson
West Phoenix
Downtown Phoenix
Sky Harbor
Downtown Tempe
East Tempe
Main Street
Mesa
Goodyear
Buckeye
Central Avenue South
Up Tempe Branch
UP Chandler Branch
Chandler Boulevard
Power Road
Gilbert
Williams Gateway
Queen Creek
Legend
Freeway
Proposed Freeway/Parkway/Highway
Major Arterials
Station
Connection
CP/EV LRT
Existing Express BRT
Proposed Express BRT
LRT/Dedicated BRT
Short Term
Medium Term
Long Term
Commuter Rail
Short Term
Medium Term
Long Term
0 1.25 2.5 5 7.5 10 Miles
IBI GROUP
Stantec
nelson\nygaard consulting associates
May 5, 2003

11.3 LRT-BRT Technology Comparison

The Benefit Cost analysis presented in Section 9 includes a comparison of LRT and BRT technologies on two of the recommended high capacity transit corridors, Main Street and 59th Avenue. This comparison is primarily related to the overall cost for each project as actual differences in ridership are not available given the sketch planning model's limitations in distinguishing between the two technologies. From a cost standpoint BRT would likely provide more benefit than LRT in a specific corridor. However, there are other issues including ridership, frequency of service, and overall capacity that also must be considered before a recommended technology can be selected. In high ridership corridors, LRT may be the preferred technology based upon meeting ridership demand even if there are higher capital costs involved.

The US General Accounting Office (GAO) published a report to the US Congress in September 2001 comparing LRT and BRT technologies for the purposes for evaluating future transit projects applying for Federal funding assistance. This report analyzed the capital and operating costs of both technologies as well as the real-world performance of each technology.

In terms of capital cost, the GAO report found that BRT has a decided advantage over LRT[5]. BRT systems surveyed in cities through the United States reported capital costs ranging from $200,000 to $55 million per mile depending upon whether the system was implemented in mixed-flow vehicle traffic or in an exclusive right-of-way. LRT systems reported an average cost of $12.4 million to $118.8 million per mile. This difference in cost correlates well with the capital cost estimates contained in Section 5.1 of this report. The Dedicated BRT corridors have an average per mile capital cost of $18.1 million, while the LRT corridors' average per mile cost is $39.7 million.

The GAO report did not reveal a major advantage for either technology in terms of operating costs. BRT typically will require more vehicles and shorter headways to provide a comparable level of service to LRT. This increased service reduces or eliminates any advantage in operating cost that a single bus would have over a single LRT train. Long term maintenance and vehicle replacement costs may favor LRT over BRT since LRT vehicles have a life cycle that is approximately double that of standard buses. The track infrastructure for LRT also usually maintains a longer life cycle than a paved BRT guideway. The annual operating costs presented for BRT and LRT in this report tend to slightly favor BRT technology. However, these planning level costs and a detailed refinement of headways and infrastructure replacement in specific corridors could eliminate this slight advantage.

In terms of operational characteristics BRT and LRT both have advantages and disadvantages that would need to be analyzed on a corridor-by-corridor

[5] GAO Report: Bus Rapid Transit Shows Promise, September 2001.

basis in order to determine the right technology "fit" for new high capacity transit system. A detailed Major Investment Study (MIS), similar to the one performed by the Cities of Scottsdale and Tempe for a north-south transit corridor, is required to fully and properly analyze each technology for a corridor. The discussion that follows presents the general advantages and disadvantages of each technology on a non-corridor specific basis.

Bus Rapid Transit

Advantages

- Increased flexibility in operating environments (streets, HOV lanes, dedicated lanes, freight corridors)
- More flexible in phasing of expended service
- Ability to operate as short-term service prior to expanded BRT or LRT service

Disadvantages

- Image of bus vehicles as slow and dirty
- Reduced vehicle capacity

Light Rail

Advantages

- Positive impact upon land use development within the corridor
- Increased vehicle capacity

Disadvantages

- Limited ability for phased implementation
- Higher capital investment cost than BRT

Summary

Both transit technologies have a series of advantages and disadvantages that require analysis at a detailed corridor specific level to determine the appropriate technology for implementation. During the technology selection process it is important to consider the influence of other corridors in the regional recommended network. Each of these technologies is highly scalable and the implementation of one technology tends to encourage the continuation of that technology in future expansions and extensions of the initial corridor. This trend is a result of the economies of scale gained for expanding existing infrastructure and the possible negative effects on total ridership caused by bus-rail transfers. However, selecting one technology over the other does not preclude the implementation of both LRT and BRT in the same metropolitan region. These two technologies co-exist in many regions including Los Angeles, Pittsburgh, and Cleveland. In the end, technology selection is not only a local decision, it is a regional one that should include input from all stakeholders region-wide to order to bring the greatest benefit to the largest number of people.

11.4 Action Plan

The Recommended High Capacity Transit Network represents the culmination of a process that identified potential high capacity transit corridors throughout the region, refined these corridors, and evaluated them against each other to determine which corridors were best suited to serve growing demand for transportation capacity in the MAG region.

The next step in implementing the recommended network is the inclusion of these corridors in the development of the RTP. This study was the first step in the process of implementation. The next step is the RTP process which will involve a second review of the network corridors, a review of expect funding availability for transit improvements, and consultations with local agencies and the general public to further refine the number an coverage of the recommended corridors. This second review should result in a more precise prioritization of the corridors based upon further refined population projections, anticipated funding, and local agency support.

There are several specific next steps that need to be taken by MAG or local agencies in the MAG region either individually or in concert to ensure that proper preparations are made for providing future high capacity transit service in several of the corridors identified in the recommended network. Ideally these actions would begin immediately; however, given the need for approval of the RTP and its funding plan, some components may need to wait until the RTP is finalized. The tasks below are designed to be realistic objectives capable of being accomplished during the next three to five years. If these tasks are not completed in this timeframe, delays may be caused to later implementation steps and could delay components of the recommended network. The immediate actions are:

Refined Prioritization of Corridors in the RTP – The RTP process may introduce changes to the prioritization categories presented in Section 5.3.3 above. These changes must be determined early on so that local agencies understand the timing for funding availability and future implementation.

Relocation of the BNSF Freight Facilities – BNSF has been considering the relocation and consolidation of several freight rail facilities in downtown Phoenix to sites north of the BNSF mainline north of the existing intermodal facility in El Mirage. The elimination of this activity could create an opportunity for the negotiation of peak period operating windows to run the Phase 1 level of service in the BNSF corridor. The use of operating windows would substantially reduce the initial capital costs of implementing commuter rail service in the BNSF corridor, delaying the addition of a second main track until later phases of service.

The relocation of the BNSF facility is not a simple process and will require extensive consultations between BNSF, local cities in the corridor, MAG, the Federal Railroad Administration (FRA), and the general public. This will likely be a long process for gaining approval of all parties involved and the identification of funding. This time frame makes it imperative that discussions begin soon to determine the feasibility of this strategy.

Begin Negotiations with Union Pacific – Negotiating access rights to freight railroad corridors can be a long drawn-out process that lasts for as many as five to 10 years depending upon the railroad, the local agency, and the operating characteristics of the corridor. It will be important to have a full understanding of what types of access rights UP will allow in both the UP Yuma and UP Southeast corridors in order to determine what capital costs will be involved in possible track upgrades and additions.

Develop a Specific Commuter Rail Network Plan – Previous studies have already considered commuter rail, largely on a corridor basis, but not in the context of the High Capacity Transit network. The revised Milestone analysis of Commuter Rail suggests very attractive ridership performance for the Startup Phase of commuter rail. The High Capacity Transit Study level of analysis does not allow this conclusion to be tested rigorously as part of a standalone Commuter Rail Analysis. A separate action-oriented plan is needed to assess the viability of the startup service, take forward the initial discussions with UP and BNSF during the course of the High Capacity Transit Study, and run the network assumptions through an analysis based on the FTA New Starts criteria.

Perform Detailed Major Investment Studies on Early Implementation Corridors – Each corridor contained within the Recommended High Capacity Transit Network will require some form of Major Investment Study (MIS) to determine precise alignments, operating characteristics, preferred technology, and the overall design of the system. An MIS report includes a detailed refinement of costs, headways, and alignments, while including opportunities for community and policy input into the development of transit service. The outcome of an MIS is usually a more defined picture of what the high capacity transit service will look like in appear and operation. Several of these MIS efforts are underway or in early planning stages and include the Scottsdale-Tempe North-South Transit MIS and the City of Chandler Transit MIS, and this recommendation is not intended to be duplicative of these efforts.

It is recommended that the Baseline corridor be included in a future Major Investment Study (MIS) to assess the suitability of high capacity transit options, which, as part of its alternatives analysis, also includes the parallel Broadway and Southern arterial streets. It also should be noted that the Central Phoenix/East Valley MIS studied high capacity transit in the City of Mesa east of the current terminus of the Central Phoenix/East Valley LRT. This MIS recommended the implementation of light rail, and as such, the recommendations of this report would not supersede this document. The work being done in these studies was incorporated into the development of corridors for evaluation in this report.

Future MIS reports will build upon the corridors identified in the Recommended High Capacity Transit Network. One of the first steps in this process will occur in the BNSF/Grand Avenue corridor where a recently announced MIS will evaluate both commuter rail and bus rapid transit alternatives.

APPENDIX A

Commuter Rail Capital Cost Estimate
Burlington Northern Santa Fe

			Phase 1	*Phase 3*
Alignment Breakdown				
Surface (main track)	linear foot		138,230	15,840
Surface (sidings)	linear foot		2,000	4,000
Bridges	each		2	
Street Crossings	each		51	15
Freeway Crossings	each			
Total Ft				
Item	**Units**	**Avg. Unit Cost**	*Phase 1*	*Phase 3*
Sound Wall	linear foot	$137	$0	$0
Grade Separations (undercrossing)	Each	$15,000,000	$0	$0
Grade Separations (overcrossing)	Each	$12,000,000	$0	$0
Earthwork	linear foot	$2	$1,402,304	$198,400
New At-grade crossing	Each	$250,000	$4,250,000	$0
Close existing crossing	Each	$140,000	$420,000	$0
Waterway Crossing	linear foot	$10,000	$5,000,000	$0
Flood Control Crossing	linear foot	$10,000	$1,000,000	$0
Subtotal-Civil			**$12,072,304**	**$198,400**
Utility Relocation	Linear ft	$165	$23,138,016	$3,273,600
Subtotal-Utilities			**$23,138,016**	**$3,273,600**
Track (ballasted)	linear foot	$145	$19,593,908	$2,659,300
Street Crossing	linear foot	$2,000	$10,200,000	$3,000,000
Special Trackwork	%	15%	$2,939,086	$398,895
Crossover - Single	Each	$150,000	$600,000	$600,000
Subtotal-Track			**$33,332,994**	**$6,658,195**
Mid-Line Stations	Each	$2,000,000	$8,000,000	$0
Transit Hub Station	Each	$4,000,000	$8,000,000	$0
Central Terminal	Each	$10,000,000	$10,000,000	$0
Surface Parking	Space	$2,800	$3,472,000	$15,414,000
Parking Structures	Space	$9,500	$0	$0
Elevated Ped Xings	Each	$1,000,000	$0	$0
Ticket Vending Machines	Each	$65,000	$910,000	$0
Subtotal-Stations			**$30,382,000**	**$15,414,000**
Centralized Traffic Control	linear foot	$140	$0	$22,969,856
CTC Control Point	each	$750,000	$0	$4,500,000
Signal Control and Switch points	each	$100,000	$0	$800,000
Subtotal-C&S			**$0**	**$28,269,856**
Maintenance/Storage	Lump Sum	$22,000,000	$0	$22,000,000
Operations Control	Mile	$100,000	$2,620,000	$0
Subtotal Facilities			**$2,620,000**	**$22,000,000**
A. Construction Subtotal			**$101,545,314**	**$75,814,051**
Environmental Mitigation	Percent of A	2%	$2,030,906	$1,516,281
B. Construction Cost Subtotal			**$103,576,220**	**$77,330,332**
Maintenance/Storage Yard	square foot	$25	$0	$22,869,000
System Envelope	mile	$2,200,000	$0	$57,596,000
New Parking Spaces	square foot	$25	$10,802,875	$47,959,550
C. Right of Way Subtotal			**$10,802,875**	**$128,424,550**
Revenue Vehicles (cab car, bi-level, 135 pass)	Each	$3,000,000	$12,000,000	$21,000,000
Revenue Vehicles (non cab, bi-level, 135 pass.)	Each	$2,000,000	$36,000,000	$28,000,000
Revenue Vehicles (loco)	Each	$4,000,000	$16,000,000	$28,000,000
Spare Parts	Percent	10%	$6,400,000	$7,700,000
MOW Equipment	Rt Mile	$250,000	$6,545,000	$750,000
D. Vehicles Subtotal			**$76,945,000**	**$85,450,000**
Cost Contingencies (Uncertainties, Changes)				
Design&Construction	Percent of B	25%	$25,894,055	$19,332,583
Right of Way	Percent of C	30%	$3,240,863	$38,527,365
Vehicle Cost	Percent of D	10%	$7,694,500	$8,545,000
Program Implementation (Agency Costs and Fees)				
Design&Construction	Percent of B	31%	$32,108,628	$23,972,403
Right of Way Purchase	Percent of C	15%	$1,620,431	$19,263,683
Vehicle Procurement	Percent of D	5%	$3,847,250	$4,272,500
E. Capital Cost Subtotal			**$265,729,823**	**$405,118,415**
Project Reserve	Percent of E	10%	$26,572,982	$40,511,842
F. Total Capital Cost			**$292,302,805**	**$445,630,257**

$737,933,062

Commuter Rail Capital Costs
Union Pacific Mainline/Chandler Corridor

			Phase 1	Phase 3
Alignment Breakdown				
Surface (main track)	linear foot		78,936	14,889
Upgraded Track			45,461	
Surface (siding)	linear foot		0	4,000
Bridges	each			
Street Crossings	each		49	5
Item	**Units**	**Avg. Unit Cost**	***Phase 1***	***Phase 3***
Sound Wall	linear foot	$137	$3,616,800	$0
Grade Separations (undercrossing)	Each	$15,000,000	$0	$0
Grade Separations (overcrossing)	Each	$12,000,000	$0	$0
Earthwork	linear foot	$2	$789,360	$188,890
New At-grade crossing	Each	$250,000	$2,500,000	$0
Close existing crossing	Each	$140,000	$0	$0
Waterway Crossing	linear foot	$10,000	$13,200,000	$0
Flood Control Crossing	linear foot	$10,000	$3,000,000	$0
Subtotal-Civil			**$23,106,160**	**$188,890**
Utility Relocation	linear foot	$165	$13,024,440	$3,116,685
Subtotal-Utilities			**$13,024,440**	**$3,116,685**
Track	linear foot	$145	$10,735,220	$2,666,405
Upgrade Track	linear foot	$120	$5,455,296	$0
Street Crossing	linear foot	$2,000	$9,800,000	$1,000,000
Special Trackwork	%	15%	$1,610,283	$399,961
Crossover - Single	Each	$150,000	$600,000	$600,000
Subtotal-Track			**$28,200,799**	**$4,666,366**
Mid-Line Stations	Each	$2,000,000	$10,000,000	$0
Transit Hub Station	Each	$4,000,000	$8,000,000	$0
Central Terminal	Each	$10,000,000	$10,000,000	$0
Surface Parking	Space	$2,800	$2,240,000	$3,570,000
Parking Structures	Space	$9,500	$0	$0
Elevated Ped Xings	Each	$1,000,000	$0	$0
Ticket Vending Machines	Each	$65,000	$1,040,000	$0
Subtotal-Stations			**$31,280,000**	**$3,570,000**
Centralized Traffic Control	linear foot	$140	$13,135,584	$9,008,972
CTC Control Point	each	$750,000	$2,250,000	$1,500,000
Signal Control and Switch points	each	$100,000	$400,000	$400,000
Subtotal-C&S			**$15,785,584**	**$10,908,972**
Maintenance/Storage	Each	$15,000,000	$0	$15,000,000
Operations Control	Mile	$100,000	$2,800,000	$0
Subtotal Facilities			**$2,800,000**	**$15,000,000**
A. Construction Subtotal			**$114,196,983**	**$37,450,913**
Environmental Mitigation	Percent of A	2%	$2,283,940	$749,018
B. Construction Cost Subtotal			**$116,480,923**	**$38,199,931**
Maintenance/Storage Yard	Lump	$25	$0	$16,335,000
System Envelope	mile	$2,200,000	$0	$39,094,000
New Parking Spaces	square foot	$25	$6,969,600	$11,107,800
C. Right of Way Subtotal			**$6,969,600**	**$66,536,800**
Revenue Vehicles (cab car, bi-level, 135 pass)	Each	$3,000,000	$12,000,000	$21,000,000
Revenue Vehicles (non cab, bi-level, 135 pass.)	Each	$2,000,000	$8,000,000	$14,000,000
Revenue Vehicles (loco)	Each	$4,000,000	$16,000,000	$28,000,000
Spare Parts	Percent	10%	$3,600,000	$6,300,000
MOW Equipment	Rt Mile	$250,000	$6,987,500	$750,000
D. Vehicles Subtotal			**$46,587,500**	**$70,050,000**
Cost Contingencies (Uncertainties, Changes)				
Design&Construction	Percent of B	25%	$29,120,231	$9,549,983
Right of Way	Percent of C	30%	$2,090,880	$19,961,040
Vehicle Cost	Percent of D	10%	$4,658,750	$7,005,000
Program Implementation (Agency Costs and Fees)				
Design&Construction	Percent of B	31%	$36,109,086	$11,841,979
Right of Way Purchase	Percent of C	15%	$1,045,440	$9,980,520
Vehicle Procurement	Percent of D	5%	$2,329,375	$3,502,500
E. Capital Cost Subtotal			**$245,391,784**	**$236,627,752**
Project Reserve	Percent of E	10%	$24,539,178	$23,662,775
F. Total Capital Cost			**$269,930,963**	**$260,290,528**

Note: All costs are in Year 2001 Dollars

Commuter Rail Capital Costs
Union Pacific Southeast

			Phase 1	Phase 3
Alignment Breakdown				
Surface (main track)	linear foot		78,936	14,890
Surface (siding)	linear foot			18,560
Bridges	each		1	
Street Crossings	each		34	4
Freeway Crossings	linear foot			
Total Ft				
Item	**Units**	**Avg. Unit Cost**	**Phase 1**	**Phase 3**
Sound Wall	linear foot	$137	$4,340,160	$0
Grade Separations (undercrossing)	Each	$15,000,000	$0	$0
Grade Separations (overcrossing)	Each	$12,000,000	$0	$0
New At-grade crossing	Each	$250,000	$3,500,000	$0
Close existing crossing	Each	$140,000	$0	$0
Earthwork	linear foot	$2	$789,360	$334,500
Waterway Crossing	linear foot	$10,000	$13,200,000	$0
Flood Control Crossing	linear foot	$10,000	$3,000,000	$0
Subtotal-Civil			**$24,829,520**	**$334,500**
Utility Relocation	linear ft	$165	$13,024,440	$903,150
Subtotal-Utilities			**$13,024,440**	**$903,150**
Track	linear foot	$145	$10,952,720	$4,792,250
Street Crossing	linear foot	$2,000	$6,800,000	$800,000
Special Trackwork	%	15%	$1,642,908	$718,838
Crossover - Single	Each	$150,000	$300,000	$1,200,000
Subtotal-Track			**$19,695,628**	**$7,511,088**
Mid-Line Stations	Each	$2,000,000	$10,000,000	$0
Transit Hub Station	Each	$4,000,000	$8,000,000	$0
Central Terminal	Each	$10,000,000	$10,000,000	$0
Surface Parking	Space	$2,800	$2,478,000	$5,124,000
Parking Structures	Space	$9,500	$0	$0
Elevated Ped Xings	Each	$1,000,000	$0	$0
Ticket Vending Machines	Each	$65,000	$1,040,000	$0
Subtotal-Stations			**$31,518,000**	**$5,124,000**
Centralized Traffic Control	linear foot	$140	$13,135,584	$15,105,720
CTC Control Point	each	$750,000	$2,250,000	$3,000,000
Signal Control and Switch points	each	$100,000	$200,000	$800,000
Subtotal-C&S			**$15,585,584**	**$18,905,720**
Maintenance/Storage	Lump Sum	$17,000,000	$0	$17,000,000
Operations Control	Mile	$100,000	$3,620,000	$0
Subtotal Facilities			**$3,620,000**	**$17,000,000**
A. Construction Subtotal			**$108,273,172**	**$49,778,458**
Environmental Mitigation	Percent of A	2%	$2,165,463	$995,569
B. Construction Cost Subtotal			**$110,438,635**	**$50,774,027**
Maintenance/Storage Yard	square foot	$25	$0	$18,513,000
System Envelope	mile	$2,200,000	$0	$39,094,000
New Parking Spaces	square foot	$25	$7,715,325	$15,932,500
C. Right of Way Subtotal			**$7,715,325**	**$73,539,500**
Revenue Vehicles (cab car, bi-level, 135 pass)	Each	$3,000,000	$12,000,000	$24,000,000
Revenue Vehicles (non cab, bi-level, 135 pass.)	Each	$2,000,000	$14,000,000	$10,000,000
Revenue Vehicles (loco)	Each	$4,000,000	$16,000,000	$32,000,000
Spare Parts	Percent	10%	$4,200,000	$6,600,000
MOW Equipment	Rt Mile	$250,000	$7,967,500	$705,019
D. Vehicles Subtotal			**$54,167,500**	**$73,305,019**
Cost Contingencies (Uncertainties, Changes)				
Design&Construction	Percent of B	25%	$27,609,659	$12,693,507
Right of Way	Percent of C	30%	$2,314,598	$22,061,850
Vehicle Cost	Percent of D	10%	$5,416,750	$7,330,502
Program Implementation (Agency Costs and Fees)				
Design&Construction	Percent of B	31%	$34,235,977	$15,739,948
Right of Way Purchase	Percent of C	15%	$1,157,299	$11,030,925
Vehicle Procurement	Percent of D	5%	$2,708,375	$3,665,251
E. Capital Cost Subtotal			**$245,764,118**	**$270,140,528**
Project Reserve	Percent of E	10%	$24,576,412	$27,014,053
F. Total Capital Cost			**$270,340,529**	**$297,154,581**

Note: All costs are in Year 2001 Dollars

Commuter Rail Capital Cost Estimate
Union Pacific Yuma Corridor

			Phase 1	Phase 3	
Alignment Breakdown					
Surface (main track)	linear foot		-	0	
Surface (sidings)	linear foot		0	10,560	
Bridges	each				
Street Crossings	each		0	2	
Freeway Crossings	linear foot				
Total Ft					
Item	**Units**	**Avg. Unit Cost**	*Phase 1*	*Phase 3*	
Sound Wall	linear foot	$137	$0	$1,808,400	
Grade Separations (undercrossing)	Each	$15,000,000	$0	$0	
Grade Separations (overcrossing)	Each	$12,000,000	$0	$0	
Earthwork	linear foot	$2	$0	$105,600	
New At-grade crossing	Each	$250,000	$1,250,000	$0	
Close existing crossing	Each	$140,000	$0	$0	
Waterway Crossing	linear foot	$10,000	$0	$0	
Flood Control Crossing	linear foot	$10,000	$0	$0	
Subtotal-Civil			**$1,250,000**	**$1,914,000**	
Utility Relocation	Linear ft	$165	$0	$1,742,400	
Subtotal-Utilities			**$0**	**$1,742,400**	
Track (ballasted)	linear foot	$145	$0	$1,531,200	
Street Crossing	linear foot	$2,000	$0	$400,000	
Special Trackwork	%	15%	$0	$229,680	
Crossover - Single	Each	$150,000	$0	$300,000	
Subtotal-Track			**$0**	**$2,460,880**	
Mid-Line Stations	Each	$2,000,000	$6,000,000	$0	
Transit Hub Station	Each	$4,000,000	$4,000,000	$0	
Central Terminal	Each	$10,000,000	$10,000,000	$0	
Surface Parking	Space	$2,800	$3,416,000	$11,760,000	
Parking Structures	Space	$9,500	$0	$0	
Elevated Ped Xings	Each	$1,000,000	$0	$0	
Ticket Vending Machines	Each	$65,000	$650,000	$0	
Subtotal-Stations			**$24,066,000**	**$11,760,000**	
Centralized Traffic Control	linear foot	$140	$0	$24,304,896	
CTC Control Point	each	$750,000	$0	$3,750,000	
Signal Control and Switch points	each	$100,000	$0	$400,000	
Subtotal-C&S			**$0**	**$28,454,896**	
Maintenance/Storage Yard	Lump Sum	$20,000,000	$0	$20,000,000	
Operations Control	Mile	$100,000	$3,090,000	$0	
Subtotal Facilities			**$3,090,000**	**$20,000,000**	
A. Construction Subtotal			**$28,406,000**	**$66,332,176**	
Environmental Mitigation	Percent of A	2%	$568,120	$1,326,644	
B. Construction Cost Subtotal			**$28,974,120**	**$67,658,820**	
Right-of-way for Maintenance/Storage Yard	square foot	$25	$0	$21,780,000	
System Envelope	mile	$2,000,000	$0	$0	
Right-of-way for Parking Spaces	square foot	$25	$10,637,350	$36,538,125	
C. Right of Way Subtotal			**$10,637,350**	**$58,318,125**	
Revenue Vehicles (cab car, bi-level, 135 pass)	Each	$3,000,000	$12,000,000	$21,000,000	
Revenue Vehicles (non cab, bi-level, 135 pass.)	Each	$2,000,000	$20,000,000	$22,000,000	
Revenue Vehicles (loco)	Each	$4,000,000	$16,000,000	$28,000,000	
Spare Parts	Percent	10%	$4,800,000	$7,100,000	
MOW Equipment	Mile	$250,000	$7,725,000	$500,000	
D. Vehicles Subtotal			**$60,525,000**	**$78,600,000**	
Cost Contingencies (Uncertainties, Changes)					
Design&Construction	Percent of B	25%	$7,243,530	$16,914,705	
Right of Way	Percent of C	30%	$3,191,205	$17,495,438	
Vehicle Cost	Percent of D	10%	$6,052,500	$7,860,000	
Program Implementation (Agency Costs and Fees)					
Design&Construction	Percent of B	31%	$8,981,977	$20,974,234	
Right of Way Purchase	Percent of C	15%	$1,595,603	$8,747,719	
Vehicle Procurement	Percent of D	5%	$3,026,250	$3,930,000	
E. Capital Cost Subtotal			**$130,227,535**	**$280,499,040**	
Project Reserve	Percent of E	10%	$13,022,753	$28,049,904	
F. Total Capital Cost			**$143,250,288**	**$308,548,944**	$451,799,232

BNSF Corridor Phase 1

CR - Fleet Sizing and O&M Estimate

Item			**Comments**
			peak
Travel/Track Miles of Line	26.18	26.18	headway
Stations:			**60**
* Surface	see total -------------	7	on each line
* Aerial	see total -------------	-	
Operating Times:			
* 1-way run, minutes	*48.3*		
Round trip w/o recovery (min)	97		excluding turn-around time at ends of line
* 2-way cycle, minutes	**97**		average cycle
Vehicle Fleet:			
* Trains in service (peak)	3	3	combined - 60' peak headways (H)
Pass Cars (6-car consist)	18	18	
* Cars in service (peak)	18	18	
* Fleet		22	In service + 20% spares
Train & Car Hrs & Miles:			
* Train Hours:			
- Daily	5	5	
* Car Hrs per day:			
- Base	5	5	
- Peak	25	25	
- Crush	0	-	
- Total	30	30	
* Car miles per day	942	942	
* Train miles per day	157		
* Annualization:			300 equivalent weekdays/year
- Car Hours	9,000	9,000	
- Car Miles	282,744	282,744	
O&M Cost Estimates:			
* Rev. Veh Hrs @ $487.64		$ 4.4	$ millions
* Rev Veh Mi @ $16.81		$ 4.8	$ millions
* ROW Lease @ $6.00/train mile		$ 0.3	$ millions
*** Total Annual O&M**		**$ 4.9**	$ millions

* Total Annual O&M Cost is computed using an average of the model inputs for revenue hours and revenue miles, plus the cost of lease track rights for Phase 1.

BNSF Corridor Phase 3

CR - Fleet Sizing and O&M Estimate

Item			Comments	
				peak
Travel/Track Miles of Line	26.18	26.18		headway
Stations:				15
* Surface	see total -------------	7		on each line
Operating Times:				
* 1-way run, minutes	*48.3*			
* 2-way cycle, minutes	**97**		average cycle	
Vehicle Fleet:				
* Trains in service (peak)	8	8	combined - 15' peak headways (H)	
Pass Cars (4-car consist)	32	32		
* Cars in service (peak)	32	32		
* Fleet		38	In service + 20% spares	
Train & Car Hrs & Miles:				
* Train Hours:				
- Peak	29			
- Off-Peak	15			
- Total	44	44		
* Car Hrs per day:				
- Peak	116	116		
- Off-Peak	30	30		
- Crush	0	-		
- Total	146	146		
* Car miles per day	4,709	4,709		
* Peak Train miles per day	942			
* Off-Peak Train miles per day	471			
* Total Train miles per day	1,413			
* Annualization:			300 equivalent weekdays/year	
- Car Hours	43,800	43,800		
- Car Miles	1,412,775	1,412,775		
O&M Cost Estimates:				
* Rev. Veh Hrs @ $487.64		$ 21.4	$ millions	
* Rev Veh Mi @ $16.81		$ 23.7	$ millions	
*** Total Annual O&M**		**$ 22.6**	$ millions	

* Total Annual O&M Cost is computed using an average of the model inputs for revenue hours and revenue miles.

UP Mainline/Chandler Corridor Phase 1
CR - Fleet Sizing and O&M Estimate

Item			Comments	
				peak
Travel/Track Miles of Line	25.95	25.95		headway
Stations:				60
* Surface	see total -------------	8		on each line
* Aerial	see total -------------	-		
Operating Times:				
* 1-way run, minutes	*49.1*			
Round trip w/o recovery (min)	98		excluding turn-around time at ends of line	
* 2-way cycle, minutes	**98**		average cycle	
Vehicle Fleet:				
* Trains in service (peak)	3	3	combined - 60' peak headways (H)	
Pass Cars (2-car consist)	6	6		
* Cars in service (peak)	6	6		
* Fleet		7	In service + 20% spares	
Train & Car Hrs & Miles:				
* Train Hours:				
- Daily	5	5		
* Car Hrs per day:				
- Base	5	5		
- Peak	10	10		
- Crush	0	-		
- Total	10	10		
* *Schedule* speed, mph	15.8		Includes dwell and recovery times	
* Car miles per day	311	311		
* Train miles per day	156			
* Annualization:			300 equivalent weekdays/year	
- Car Hours	3,000	3,000		
- Car Miles	93,420	93,420		
O&M Cost Estimates:				
* Rev. Veh Hrs @ $487.64		$ 1.5	$ millions	
* Rev Veh Mi @ $16.81		$ 1.6	$ millions	
* ROW Lease @ $6.00/train mile		$ 0.3	$ millions	
*** Total Annual O&M**		**$ 1.9**	$ millions	

* Total Annual O&M Cost is computed using an average of the model inputs for revenue hours and revenue miles, plus the cost of lease track rights for Phase 1.

Up Mainline/Chandler Corridor Phase 3
CR - Fleet Sizing and O&M Estimate

Item			Comments	
				peak
Travel/Track Miles of Line	25.95	25.95		headway
Stations:				15
* Surface	see total -------------	8		on each line
Operating Times:				
* 1-way run, minutes	*49.1*			
* 2-way cycle, minutes	**98**		average cycle	
Vehicle Fleet:				
* Trains in service (peak)	9	9	combined - 15' peak headways (H)	
Pass Cars (2-car consist)	18	18		
* Cars in service (peak)	18	18		
* Fleet		22	In service + 20% spares	
Train & Car Hrs & Miles:				
* Train Hours:				
- Peak	30			
- Off-Peak	15			
- Total	45	45		
* Car Hrs per day:				
- Peak	60	60		
- Off-Peak	30	30		
- Crush	0	-		
- Total	90	90		
* Car miles per day	2,802	2,802		
* Peak Train miles per day	934			
* Off-Peak Train miles per day	467			
* Total Train miles per day	1,401			
* Annualization:			300 equivalent weekdays/year	
- Car Hours	27,000	27,000		
- Car Miles	840,494	840,494		
O&M Cost Estimates:				
* Rev. Veh Hrs @ $487.64		$ 13.2	$ millions	
* Rev Veh Mi @ $16.81		$ 14.1	$ millions	
* ROW Lease @ $6.00/train mile		$ 0.6	$ millions	
*** Total Annual O&M**		**$ 14.3**	$ millions	

* Total Annual O&M Cost is computed using an average of the model inputs for revenue hours and revenue miles, plus the cost of leasing track rights along the Chandler Industrial Branch.

UP Southeast Corridor Phase 1
CR - Fleet Sizing and O&M Estimate

Item			Comments
			peak headway **60** on each line
Travel/Track Miles of Line	31.87	31.87	
Stations:			
* Surface	see total -------------	8	
Operating Times:			
* 1-way run, minutes	*56.2*		
* 2-way cycle, minutes	**112**		average cycle
Vehicle Fleet:			
* Trains in service (peak)	3	3	combined - 60' peak headways (H)
Pass Cars (3-car consist)	9	9	
* Cars in service (peak)	9	9	
* Fleet		11	In service + 20% spares
Train & Car Hrs & Miles:			
* Train Hours:			
- Daily	6	6	
* Car Hrs per day:			
- Base	6	6	
- Peak	12	12	
- Crush	0	-	
- Total	18	18	
* Car miles per day	574	574	
* Train miles per day	191		
* Annualization:			300 equivalent weekdays/year
- Car Hours	5,400	5,400	
- Car Miles	172,098	172,098	
O&M Cost Estimates:			
* Rev. Veh Hrs @ $487.64		$2.60	$ millions
* Rev Veh Mi @ $16.81		$2.90	$ millions
* ROW Lease @ $6.00/train mile		$0.30	$ millions
*** Total Annual O&M**		**$3.05**	$ millions

* Total Annual O&M Cost is computed using an average of the model inputs for revenue hours and revenue miles, plus the cost of lease track rights for Phase 1.

UP Southeast Corridor Phase 3

CR - Fleet Sizing and O&M Estimate

Item			**Comments**	
				peak
Travel/Track Miles of Line	31.87	31.87		headway
Stations:				15
* Surface	see total -------------	8		on each line
Operating Times:				
* 1-way run, minutes	*56.2*			
* 2-way cycle, minutes	**112**		average cycle	
Vehicle Fleet:				
* Trains in service (peak)	10	10	combined - 15' peak headways (H)	
Pass Cars (2-car consist)	20	20		
* Cars in service (peak)	20	20		
* Fleet		24	In service + 20% spares	
Train & Car Hrs & Miles:				
* Train Hours:				
- Peak	34			
- Off-Peak	17			
- Total	51	51		
* Car Hrs per day:				
- Peak	68	68		
- Off-Peak	34	34		
- Crush	0	-		
- Total	102	102		
* Car miles per day	3,439	3,439		
* Peak Train miles per day	1,146			
* Off-Peak Train miles per day	573			
* Total Train miles per day	1,720			
* Annualization:			300 equivalent weekdays/year	
- Car Hours	30,600	30,600		
- Car Miles	1,031,832	1,031,832		
O&M Cost Estimates:				
* Rev. Veh Hrs @ $487.64		$ 14.9	$ millions	
* Rev Veh Mi @ $16.81		$ 17.3	$ millions	
* ROW Lease @ $6.00/train mile		$ 1.4	$ millions	
*** Total Annual O&M**		**$ 17.5**	$ millions	

* Total Annual O&M Cost is computed using an average of the model inputs for revenue hours and revenue miles, plus the cost of lease track rights between Baseline Road and Ellsworth Avenue.

Up Yuma Corridor Phase 1
CR - Fleet Sizing and O&M Estimate

Item			Comments
			peak headway 60 on each line
Travel/Track Miles of Line	30.90	30.90	
Stations:			
* Surface	see total -------------	5	
Operating Times:			
* 1-way run, minutes	*46.1*		
* 2-way cycle, minutes	**92**		average cycle
Vehicle Fleet:			
* Trains in service (peak)	3	3	combined - 60' peak headways (H)
Pass Cars (4-car consist)	12	12	
* Cars in service (peak)	12	12	
* Fleet		14	In service + 20% spares
Train & Car Hrs & Miles:			
* Train Hours:			
- Daily	5	5	
* Car Hrs per day:			
- Base	5	5	
- Peak	15	15	
- Crush	0	-	
- Total	20	20	
* Car miles per day	742	742	
* Train miles per day	185		
* Annualization:			300 equivalent weekdays/year
- Car Hours	6,000	6,000	
- Car Miles	222,480	222,480	
O&M Cost Estimates:			
* Rev. Veh Hrs @ $487.64		$ 2.9	$ millions
* Rev Veh Mi @ $16.81		$ 3.7	$ millions
* ROW Lease @ $6.00/train mile		$ 0.3	$ millions
*** Total Annual O&M**		**$ 3.6**	$ millions

* Total Annual O&M Cost is computed using an average of the model inputs for revenue hours and revenue miles, plus the cost of lease track rights for Phase 1.

UP Yuma Corridor Phase 3

CR - Fleet Sizing and O&M Estimate

Item			**Comments**	
				peak
Travel/Track Miles of Line	30.90	30.90		headway
Stations:				**15**
* Surface	see total -------------	5		on each line
Operating Times:				
* 1-way run, minutes	*46.1*			
* 2-way cycle, minutes	**92**		average cycle	
Vehicle Fleet:				
* Trains in service (peak)	9	9	combined - 15' peak headways (H)	
Pass Cars (3-car consist)	27	27		
* Cars in service (peak)	27	27		
* Fleet		32	In service + 20% spares	
Train & Car Hrs & Miles:				
* Train Hours:				
- Peak	28			
- Off-Peak	14			
- Total	42	42		
* Car Hrs per day:				
- Peak	84	84		
- Off-Peak	28	28		
- Crush	0	-		
- Total	112	112		
* Car miles per day	4,448	4,448		
* Peak Train miles per day	1,112			
* Off-Peak Train miles per day	556			
* Total Train miles per day	1,668			
* Annualization:			300 equivalent weekdays/year	
- Car Hours	33,600	33,600		
- Car Miles	1,334,318	1,334,318		
O&M Cost Estimates:				
* Rev. Veh Hrs @ $487.64		$ 16.4	$ millions	
* Rev Veh Mi @ $16.81		$ 22.4	$ millions	
* ROW Lease @ $6.00/train mile		$ 3.0	$ millions	
*** Total Annual O&M**		**$ 22.4**	$ millions	

* Total Annual O&M Cost is computed using an average of the model inputs for revenue hours and revenue miles, plus the cost of lease track rights.

APPENDIX B

Light Rail Transit Estimated Costs
(Ballasted Track)

Item	Units	Avg. Unit Cost	Amount	*Bell Road*	*Amount*	*Chandler Boulevard*	*Amount*	*Power Road*
Alignment Breakdown								
Surface (Median)	linear ft			142,848		71,036		66,224
Surface (Rail ROW, Freeway)	linear ft							
Freeway/Bridge Crossings (Locations)	linear ft			7,920		15,840		2,640
Elevated (Aerial Locations)	linear ft							
Elevated/Special (Aerial Locations)	linear ft							
Street Crossings	each							
Intersections	each			100		68		45
Signal Intersections	each			69		45		35
Basic intersection traffic mitigation	Each	$53,000				$0		$0
Intersection Modifications (Spot widening)	Each	$320,000				$0		$0
Modify/Move Traffic Signals	Sig. Intrsctn	$65,000	69	$4,485,000	45	$2,925,000	35	$2,275,000
Roadway Widening	linear ft	$275	142,848	$39,283,200	71,036	$19,534,900	66,224	$18,211,600
New at-grade crossing (in freight railway)	Each	$265,000						
Civil/Roadway Modifications (at intersections)	linear ft	$230	10,000	$2,300,000	6,800	$1,564,000	4,500	$1,035,000
Subtotal-Civil Site Mods				**$46,068,200**		**$24,023,900**		**$21,521,600**
Surface Track Embedded in Street	linear ft	$472	10,000	$4,720,000	6,800	$3,209,600	4,500	$2,124,000
Surface Track Ballast	linear ft	$159	132,848	$21,122,832	64,236	$10,213,524	61,724	$9,814,116
Dual Track Aerial	Aerial Rt Ft	$4,000	7,920	$31,680,000	15,840	$63,360,000	2,640	$10,560,000
Long Span Aerial Structures	Aerial Rt Ft	$8,000						
Subtotal-Guideway				**$57,522,832**		**$76,783,124**		**$22,498,116**
Utility Relocation	Linear ft	$425	150,768	$64,076,400	86,876	$36,922,300	68,864	$29,267,200
Subtotal-Utilities				**$64,076,400**		**$36,922,300**		**$29,267,200**
Direct Fixation Track (on structure)	linear ft	$490	7,920	$3,880,800	15,840	$7,761,600	2,640	$1,293,600
Ballast Track (at-grade)	linear ft	$345	132,848	$45,832,560	64,236	$22,161,420	61,724	$21,294,780
Embedded Track (in pavement)	linear ft	$495	10,000	$4,950,000	6,800	$3,366,000	4,500	$2,227,500
Subtotal-Track				**$54,663,360**		**$33,289,020**		**$24,815,880**
Surface Stations	Each	$900,000	25	$22,500,000	12	$10,800,000	12	$10,800,000
Aerial Stations	Each	$3,000,000	2	$6,000,000	3	$9,000,000	0	$0
Hub Station (surface)	Each	$1,500,000	2	$3,000,000	2	$3,000,000	1	$1,500,000
Surface Parking	Space	$3,000	2,175	$6,525,000	1,275	$3,825,000	975	$2,925,000
Parking Structures	Space	$10,000	2,175	$21,750,000	1,275	$12,750,000	975	$9,750,000
Elevated Ped Xings	Each	$1,000,000	2	$2,000,000	3	$3,000,000	1	$1,000,000
Subtotal-Stations				**$61,775,000**		**$42,375,000**		**$25,975,000**
Ticket Vending Machines	Station	$390,000	29	$11,310,000	17	$6,630,000	13	$5,070,000
Substations	Each	$1,150,000	29	$33,350,000	17	$19,550,000	13	$14,950,000
Overhead Catenary	linear ft	$195	150,768	$29,399,760	86,876	$16,940,820	68,864	$13,428,480
Catenary Foundations	linear ft	$55	142,848	$7,856,640	71,036	$3,906,980	66,224	$3,642,320
Communications/Signals	linear ft	$245	150,768	$36,938,160	86,876	$21,284,620	68,864	$16,871,680
Crossover Interlockings	Each	$210,000	14	$2,940,000	8	$1,680,000	7	$1,365,000
Duct Bank - Aerial	Aerial Rt Ft	$37	7,920	$293,040	15,840	$586,080	2,640	$97,680
Duct Bank - At Grade	linear ft	$37	142,848	$5,285,376	71,036	$2,628,332	66,224	$2,450,288
Lighting At Grade	Surfc Rt Mile	$375,000	29	$10,706,250	16	$6,168,750	13	$4,875,000
Subtotal-Sys Electrical				**$138,079,226**		**$79,375,582**		**$62,750,448**
Maintenance/Storage	Each			$10,000,000		$5,000,000		$3,000,000
Operations Control	Each			$2,500,000		$2,500,000		$2,500,000
Subtotal - Facilities				**$12,500,000**		**$7,500,000**		**$5,500,000**
A. Construction Subtotal				**$434,685,018**		**$300,268,926**		**$192,328,244**
Environmental Mitigation	Percent of A	2%		$8,693,700		$6,005,379		$3,846,565
B. Construction Cost Subtotal				**$443,378,718**		**$306,274,305**		**$196,174,809**
System Envelope	square foot	$25	3,055,504	$76,387,600	1,477,428	$36,935,700	1,419,652	$35,491,300
New Parking Spaces	square foot	$25	1,010,592	$25,264,800	592,416	$14,810,400	453,024	$11,325,600
C. Right of Way Subtotal				**$101,652,400**		**$51,746,100**		**$46,816,900**
Revenue Vehicles	Each	$3,000,000	41	$123,000,000	17	$51,000,000	12	$36,000,000
Spare Parts	Percent	10%		$12,300,000		$5,100,000		$3,600,000
MOW Equipment	Rt Mile	$225,000	29	$6,412,500	16	$3,701,250	13	$2,925,000
D. Vehicles Subtotal				**$141,712,500**		**$59,801,250**		**$42,525,000**
Cost Contingencies (Uncertainties, Changes)								
Design&Construction	Percent of B	25%		$110,844,680		$76,568,576		$49,043,702
Right of Way	Percent of C	30%		$30,495,720		$15,523,830		$14,045,070
Vehicle Cost	Percent of D	10%		$14,171,250		$5,980,125		$4,252,500
Program Implementation (Agency Costs and Fees)								
Design&Construction	Percent of B	31%		$137,447,403		$94,945,034		$60,814,191
Right of Way Purchase	Percent of C	15%		$15,247,860		$7,761,915		$7,022,535
Vehicle Procurement	Percent of D	5%		$7,085,625		$2,990,063		$2,126,250
E. Capital Cost Subtotal				**$1,002,036,156**		**$621,591,198**		**$422,820,957**
Project Reserve	Percent of E	10%		$100,203,616		$62,159,120		$42,282,095.69
F. Total Capital Cost				**$1,102,239,771**		**$683,750,317**		**$465,103,053**

Note: All costs are in Year 2001 Dollars

Light Rail Transit Estimated Costs
(Ballasted Track)

Item	Units	Avg. Unit Cost	*Amount*	*SR-51*	*Amount*	*59th Avenue*	*Amount*	*I-10 West*
Alignment Breakdown								
Surface (Median)	linear ft			61,195		89,729		57,004
Surface (Rail ROW, Freeway)	linear ft							
Freeway/Bridge Crossings (Locations)	linear ft			3,960		5,280		
Elevated (Aerial Locations)	linear ft			26,400				1,340
Elevated/Special (Aerial Locations)	linear ft					5,280		
Street Crossings	each							
Intersections	each			37		106		15
Signal Intersections	each			24		54		10
Basic intersection traffic mitigation	Each	$53,000		$0		$0		$0
Intersection Modifications (Spot widening)	Each	$320,000		$0		$0		$0
Modify/Move Traffic Signals	Sig. Intrsctn	$65,000	24	$1,560,000	54	$3,510,000	10	$650,000
Roadway Widening	linear ft	$275	61,195	$16,828,625	89,729	$24,675,475	57,004	$15,676,100
New at-grade crossing (in freight railway)	Each	$265,000		$0		$0		$0
Civil/Roadway Modifications (at intersections)	linear ft	$230	3,700	$851,000	10,600	$2,438,000	1,500	$345,000
Subtotal-Civil Site Mods				**$19,239,625**		**$30,623,475**		**$16,671,100**
Surface Track Embedded in Street	linear ft	$472	3,700	$1,746,400	10,600	$5,003,200	3,940	$1,859,680
Surface Track Ballast	linear ft	$159	57,495	$9,141,705	79,129	$12,581,511	53,064	$8,437,176
Dual Track Aerial	Aerial Rt Ft	$4,000	30,360	$121,440,000	10,560	$42,240,000	1,340	$5,360,000
Long Span Aerial Structures	Aerial Rt Ft	$8,000						
Subtotal-Guideway				$132,328,105		**$59,824,711**		**$15,656,856**
Utility Relocation	Linear ft	$425	91,555	$38,910,875	100,289	$42,622,825	58,344	$24,796,200
Subtotal-Utilities				**$38,910,875**		**$42,622,825**		**$24,796,200**
Direct Fixation Track (on structure)	linear ft	$490	30,360	$14,876,400	10,560	$5,174,400	1,340	$656,600
Ballast Track (at-grade)	linear ft	$345	57,495	$19,835,775	79,129	$27,299,505	53,064	$18,307,080
Embedded Track (in pavement)	linear ft	$495	3,700	$1,831,500	10,600	$5,247,000	3,940	$1,950,300
Subtotal-Track				**$36,543,675**		**$37,720,905**		**$20,913,980**
Surface Stations	Each	$900,000	13	$11,700,000	15	$13,500,000	10	$9,000,000
Aerial Stations	Each	$3,000,000	4	$12,000,000	1	$3,000,000	0	$0
Hub Station (surface)	Each	$1,500,000	0	$0	3	$4,500,000	1	$1,500,000
Surface Parking	Space	$3,000	1,275	$3,825,000	1,425	$4,275,000	825	$2,475,000
Parking Structures	Space	$10,000	1,275	$12,750,000	1,425	$14,250,000	825	$8,250,000
Elevated Ped Xings	Each	$1,000,000	4	$4,000,000	2	$2,000,000	0	$0
Subtotal-Stations				**$44,275,000**		**$41,525,000**		**$21,225,000**
Ticket Vending Machines	Station	$390,000	17	$6,630,000	19	$7,410,000	11	$4,290,000
Substations	Each	$1,150,000	17	$19,550,000	19	$21,850,000	11	$12,650,000
Overhead Catenary	linear ft	$195	91,555	$17,853,225	100,289	$19,556,355	58,344	$11,377,080
Catenary Foundations	linear ft	$55	61,195	$3,365,725	89,729	$4,935,095	57,004	$3,135,220
Communications/Signals	linear ft	$245	91,555	$22,430,975	100,289	$24,570,805	58,344	$14,294,280
Crossover Interlockings	Each	$210,000	9	$1,890,000	9	$1,890,000	6	$1,260,000
Duct Bank - Aerial	Aerial Rt Ft	$37	30,360	$1,123,320	10,560	$390,720	1,340	$49,580
Duct Bank - At Grade	linear ft	$37	61,195	$2,264,215	89,729	$3,319,973	57,004	$2,109,148
Lighting At Grade	Surfc Rt Mile	$375,000	17	$6,502,500	19	$7,125,000	11	$4,125,000
Subtotal-Sys Electrical				**$81,609,960**		**$91,047,948**		**$53,290,308**
Maintenance/Storage	Each			$6,500,000		$5,000,000		$3,000,000
Operations Control	Each			$2,500,000		$2,500,000		$2,500,000
Subtotal - Facilities				$9,000,000		**$7,500,000**		**$5,500,000**
A. Construction Subtotal				**$361,907,240**		**$310,864,864**		**$158,053,444**
Environmental Mitigation	Percent of A	2%		$7,238,145		$6,217,297		$3,161,069
B. Construction Cost Subtotal				**$369,145,385**		**$317,082,161**		**$161,214,513**
System Envelope	square foot	$25	1,322,385	$33,059,625	1,819,967	$45,499,175	626,160	$15,654,000
New Parking Spaces	square foot	$25	592,416	$14,810,400	662,112	$16,552,800	383,328	$9,583,200
C. Right of Way Subtotal				**$47,870,025**		**$62,051,975**		**$25,237,200**
Revenue Vehicles	Each	$3,000,000	26	$78,000,000	19	$57,000,000	19	$57,000,000
Spare Parts	Percent	10%		$7,800,000		$5,700,000		$5,700,000
MOW Equipment	Rt Mile	$225,000	17	$3,901,500	19	$4,275,000	11	$2,475,000
D. Vehicles Subtotal				**$89,701,500**		**$66,975,000**		**$65,175,000**
Cost Contingencies (Uncertainties, Changes)								
Design&Construction	Percent of B	25%		$92,286,346		$79,270,540		$40,303,628
Right of Way	Percent of C	30%		$14,361,008		$18,615,593		$7,571,160
Vehicle Cost	Percent of D	10%		$8,970,150		$6,697,500		$6,517,500
Program Implementation (Agency Costs and Fees)								
Design&Construction	Percent of B	31%		$114,435,069		$98,295,470		$49,976,499
Right of Way Purchase	Percent of C	15%		$7,180,504		$9,307,796		$3,785,580
Vehicle Procurement	Percent of D	5%		$4,485,075		$3,348,750		$3,258,750
E. Capital Cost Subtotal				**$748,435,062**		**$661,644,785**		**$363,039,830**
Project Reserve	Percent of E	10%		$74,843,506.15		$66,164,479		$36,303,983.01
F. Total Capital Cost				**$823,278,568**		**$727,809,264**		**$399,343,813**

Note: All costs are in Year 2001 Dollars

Light Rail Transit Estimated Costs
(Ballasted Track)

Item	Units	Avg. Unit Cost	Amount	Union Pacific Chandler Branch	Amount	Main	Amount	Metrocenter
Alignment Breakdown								
Surface (Median)	linear ft			18,240		50,899		43,560
Surface (Rail ROW, Freeway)	linear ft			48,288		-		-
Freeway/Bridge Crossings (Locations)	linear ft							-
Elevated (Aerial Locations)	linear ft							2,640
Elevated/Special (Aerial Locations)	linear ft							
Street Crossings	each			24		-		-
Intersections	each			7		43		7
Signal Intersections	each			6		25		4
Basic intersection traffic mitigation	Each	$53,000		$0		$0		$0
Intersection Modifications (Spot widening)	Each	$320,000		$0		$0		$0
Modify/Move Traffic Signals	Sig. Intrsctn	$65,000	6	$390,000	25	$1,625,000	4	$260,000
Roadway Widening	linear ft	$275	18,240	$5,016,000	50,899	$13,997,225	43,560	$11,979,000
New at-grade crossing (in freight railway)	Each	$265,000	2	$530,000	0	$0	0	$0
Civil/Roadway Modifications (at intersections)	linear ft	$230	3,100	$713,000	4,300	$989,000	700	$161,000
Subtotal-Civil Site Mods				**$6,649,000**		**$16,611,225**		**$12,400,000**
Surface Track Embedded in Street	linear ft	$472	18,240	$8,609,280	4,300	$2,029,600	700	$330,400
Surface Track Ballast	linear ft	$159	48,288	$7,677,792	46,599	$7,409,241	42,860	$6,814,740
Dual Track Aerial	Aerial Rt Ft	$4,000	0	$0	0	$0	2,640	$10,560,000
Long Span Aerial Structures	Aerial Rt Ft	$8,000		$0		$0		$0
Subtotal-Guideway				**$16,287,072**		**$9,438,841**		**$17,705,140**
Utility Relocation	Linear ft	$425	66,528	$28,274,400	50,899	$21,632,075	46,200	$19,635,000
Subtotal-Utilities				**$28,274,400**		**$21,632,075**		**$19,635,000**
Direct Fixation Track (on structure)	linear ft	$490	0	$0	0	$0	2,640	$1,293,600
Ballast Track (at-grade)	linear ft	$345	48,288	$16,659,360	46,599	$16,076,655	42,860	$14,786,700
Embedded Track (in pavement)	linear ft	$495	18,240	$9,028,800	4,300	$2,128,500	700	$346,500
Subtotal-Track				**$25,688,160**		**$18,205,155**		**$16,426,800**
Surface Stations	Each	$900,000	11	$9,900,000	9	$8,100,000	7	$6,300,000
Aerial Stations	Each	$3,000,000	0	$0	0	$0	1	$3,000,000
Hub Station (surface)	Each	$1,500,000	2	$3,000,000	1	$1,500,000	0	$0
Surface Parking	Space	$3,000	975	$2,925,000	750	$2,250,000	600	$1,800,000
Parking Structures	Space	$10,000	975	$9,750,000	750	$7,500,000	600	$6,000,000
Elevated Ped Xings	Each	$1,000,000	0	$0	0	$0	1	$1,000,000
Subtotal-Stations				**$25,575,000**		**$19,350,000**		**$18,100,000**
Ticket Vending Machines	Station	$390,000	13	$5,070,000	10	$3,900,000	8	$3,120,000
Substations	Each	$1,150,000	13	$14,950,000	10	$11,500,000	8	$9,200,000
Overhead Catenary	linear ft	$195	66,528	$12,972,960	50,899	$9,925,305	46,200	$9,009,000
Catenary Foundations	linear ft	$55	66,528	$3,659,040	50,899	$2,799,445	43,560	$2,395,800
Communications/Signals	linear ft	$245	66,528	$16,299,360	50,899	$12,470,255	46,200	$11,319,000
Crossover Interlockings	Each	$210,000	6	$1,260,000	4	$840,000	4	$840,000
Duct Bank - Aerial	Aerial Rt Ft	$37	0	$0	0	$0	2,640	$97,680
Duct Bank - At Grade	linear ft	$37	66,528	$2,461,536	50,899	$1,883,263	43,560	$1,611,720
Lighting At Grade	Surfc Rt Mile	$375,000	13	$4,725,000	10	$3,600,000	9	$3,281,250
Subtotal-Sys Electrical				**$61,397,896**		**$46,918,268**		**$40,874,450**
Maintenance/Storage	Each			$4,750,000		$4,500,000		$2,500,000
Operations Control	Each			$2,500,000		$2,500,000		$1,000,000
Subtotal - Facilities				**$7,250,000**		**$7,000,000**		**$3,500,000**
A. Construction Subtotal				**$171,121,528**		**$139,155,564**		**$128,641,390**
Environmental Mitigation	Percent of A	2%		$3,422,431		$2,783,111		$2,572,828
B. Construction Cost Subtotal				**$174,543,959**		**$141,938,675**		**$131,214,218**
System Envelope	square foot	$25	1,514,044	$37,851,100	1,071,777	$26,794,425	1,012,180	$25,304,500
New Parking Spaces	square foot	$25	453,024	$11,325,600	348,480	$8,712,000	278,784	$6,969,600
C. Right of Way Subtotal				**$49,176,700**		**$35,506,425**		**$32,274,100**
Revenue Vehicles	Each	$3,000,000	19	$57,000,000	17	$51,000,000	14	$42,000,000
Spare Parts	Percent	10%		$5,700,000		$5,100,000		$4,200,000
MOW Equipment	Rt Mile	$225,000	13	$2,835,000	9	$1,944,000	9	$2,025,000
D. Vehicles Subtotal				**$65,535,000**		**$58,044,000**		**$48,225,000**
Cost Contingencies (Uncertainties, Changes)								
Design&Construction	Percent of B	25%		$43,635,990		$35,484,669		$32,803,554
Right of Way	Percent of C	30%		$14,753,010		$10,651,928		$9,682,230
Vehicle Cost	Percent of D	10%		$6,553,500		$5,804,400		$4,822,500
Program Implementation (Agency Costs and Fees)								
Design&Construction	Percent of B	31%		$54,108,627		$44,000,989		$40,676,408
Right of Way Purchase	Percent of C	15%		$7,376,505		$5,325,964		$4,841,115
Vehicle Procurement	Percent of D	5%		$3,276,750		$2,902,200		$2,411,250
E. Capital Cost Subtotal				**$418,960,040**		**$339,659,250**		**$306,950,375**
Project Reserve	Percent of E	10%		$41,896,004		$33,965,925		$30,695,037.48
F. Total Capital Cost				**$460,856,044**		**$373,625,175**		**$337,645,412**

Note: All costs are in Year 2001 Dollars

Light Rail Transit Estimated Costs
(Ballasted Track)

Item	Units	Avg. Unit Cost	Amount	Scottsdale/UP Tempe Combo	Amount	Glendale Avenue	Amount	Camelback Road	Amount	Central Avenue South
Alignment Breakdown										
Surface (Median)	linear ft			96,360		43,560		42,926		20,750
Surface (Rail ROW, Freeway)	linear ft			23,760		-				
Freeway/Bridge Crossings (Locations)	linear ft			3,960		7,920		2,640		5,280
Elevated (Aerial Locations)	linear ft			5,280						
Elevated/Special (Aerial Locations)	linear ft			5,280						
Street Crossings	each			7		-				
Intersections	each			110		48		42		48
Signal Intersections	each			64		29		26		22
Basic intersection traffic mitigation	Each	$53,000		$0		$0		$0		$0
Intersection Modifications (Spot widening)	Each	$320,000		$0		$0		$0		$0
Modify/Move Traffic Signals	Sig. Intrsctn	$65,000	64	$4,160,000	29	$1,885,000	26	$1,690,000	22	$1,430,000
Roadway Widening	linear ft	$275	96,360	$26,499,000	43,560	$11,979,000	42,926	$11,804,650	20,750	$5,706,360
New at-grade crossing (in freight railway)	Each	$265,000	7	$1,855,000	0	$0		$0		$0
Civil/Roadway Modifications (at intersections)	linear ft	$230	11,000	$2,530,000	4,800	$1,104,000	4,200	$966,000	4,800	$1,104,000
Subtotal-Civil Site Mods				**$35,044,000**		**$14,968,000**		**$14,460,650**		**$8,240,360**
Surface Track Embedded in Street	linear ft	$472	11,700	$5,522,400	4,800	$2,265,600	4,200	$1,982,400	4,800	$2,265,600
Surface Track Ballast	linear ft	$159	108,420	$17,238,780	38,760	$6,162,840	38,726	$6,157,434	15,950	$2,536,114
Dual Track Aerial	Aerial Rt Ft	$4,000	14,520	$58,080,000	7,920	$31,680,000	2,640	$10,560,000	5,280	$21,120,000
Long Span Aerial Structures	Aerial Rt Ft	$8,000	0	$0		$0		$0		$0
Subtotal-Guideway				**$80,841,180**		**$40,108,440**		**$18,699,834**		**$25,921,714**
Utility Relocation	Linear ft	$425	134,640	$57,222,000	51,480	$21,879,000	45,566	$19,365,550	26,030	$11,062,920
Subtotal-Utilities				**$57,222,000**		**$21,879,000**		**$19,365,550**		**$11,062,920**
Direct Fixation Track (on structure)	linear ft	$490	14,520	$7,114,800	7,920	$3,880,800	2,640	$1,293,600	5,280	$2,587,200
Ballast Track (at-grade)	linear ft	$345	108,420	$37,404,900	38,760	$13,372,200	38,726	$13,360,470	15,950	$5,502,888
Embedded Track (in pavement)	linear ft	$495	11,700	$5,791,500	4,800	$2,376,000	4,200	$2,079,000	4,800	$2,376,000
Subtotal-Track				**$50,311,200**		**$19,629,000**		**$16,733,070**		**$10,466,088**
Surface Stations	Each	$900,000	22	$19,800,000	8	$7,200,000	7	$6,300,000	5	$4,500,000
Aerial Stations	Each	$3,000,000	0	$0	2	$6,000,000	1	$3,000,000	0	$0
Hub Station (surface)	Each	$1,500,000	3	$4,500,000	0	$0	1	$1,500,000	0	$0
Surface Parking	Space	$3,000	1,875	$5,625,000	750	$2,250,000	675	$2,025,000	375	$1,125,000
Parking Structures	Space	$10,000	1,875	$18,750,000	750	$7,500,000	675	$6,750,000	375	$3,750,000
Elevated Ped Xings	Each	$1,000,000	0	$0	2	$2,000,000	1	$1,000,000	0	$0
Subtotal-Stations				**$48,675,000**		**$24,950,000**		**$20,575,000**		**$9,375,000**
Ticket Vending Machines	Station	$390,000	25	$9,750,000	10	$3,900,000	9	$3,510,000	5	$1,950,000
Substations	Each	$1,150,000	25	$28,750,000	10	$11,500,000	9	$10,350,000	5	$5,750,000
Overhead Catenary	linear ft	$195	134,640	$26,254,800	51,480	$10,038,600	45,566	$8,885,370	26,030	$5,075,928
Catenary Foundations	linear ft	$55	120,120	$6,606,600	43,560	$2,395,800	42,926	$2,360,930	20,750	$1,141,272
Communications/Signals	linear ft	$245	134,640	$32,986,800	51,480	$12,612,600	45,566	$11,163,670	26,030	$6,377,448
Crossover Interlockings	Each	$210,000	13	$2,730,000	5	$1,050,000	4	$840,000	3	$630,000
Duct Bank - Aerial	Aerial Rt Ft	$37	14,520	$537,240	7,920	$293,040	2,640	$97,680	5,280	$195,360
Duct Bank - At Grade	linear ft	$37	120,120	$4,444,440	43,560	$1,611,720	42,926	$1,588,262	20,750	$767,765
Lighting At Grade	Surfc Rt Mile	$375,000	26	$9,562,500	10	$3,656,250	9	$3,236,250	5	$1,848,750
Subtotal-Sys Electrical				**$121,622,380**		**$47,058,010**		**$42,032,162**		**$23,736,523**
Maintenance/Storage	Each			$9,500,000		$4,250,000		$3,500,000		$2,500,000
Operations Control	Each			$2,500,000		$2,000,000		$2,000,000		$2,000,000
Subtotal - Facilities				**$12,000,000**		**$6,250,000**		**$5,500,000**		**$4,500,000**
A. Construction Subtotal				**$405,715,760**		**$174,842,450**		**$137,366,266**		**$93,302,604**
Environmental Mitigation	Percent of A	2%		$8,114,315		$3,496,849		$2,747,325		$1,866,052
B. Construction Cost Subtotal				**$413,830,075**		**$178,339,299**		**$140,113,591**		**$95,168,656**
System Envelope	square foot	$25	2,509,760	$62,744,000	891,480	$22,287,000	890,698	$22,267,450	366,859	$9,171,480
New Parking Spaces	square foot	$25	871,200	$21,780,000	348,480	$8,712,000	313,632	$7,840,800	174,240	$4,356,000
C. Right of Way Subtotal				**$84,524,000**		**$30,999,000**		**$30,108,250**		**$13,527,480**
Revenue Vehicles	Each	$3,000,000	38	$114,000,000	17	$51,000,000	14	$42,000,000	10	$30,000,000
Spare Parts	Percent	10%		$11,400,000		$5,100,000		$4,200,000		$3,000,000
MOW Equipment	Rt Mile	$225,000	26	$5,737,500	10	$2,193,750	9	$1,941,750	5	$1,109,250
D. Vehicles Subtotal				**$131,137,500**		**$58,293,750**		**$48,141,750**		**$34,109,250**
Cost Contingencies (Uncertainties, Changes)										
Design&Construction	Percent of B	25%		$103,457,519		$44,584,825		$35,028,398		$23,792,164
Right of Way	Percent of C	30%		$25,357,200		$9,299,700		$9,032,475		$4,058,244
Vehicle Cost	Percent of D	10%		$13,113,750		$5,829,375		$4,814,175		$3,410,925
Program Implementation (Agency Costs and Fees)										
Design&Construction	Percent of B	31%		$128,287,323		$55,285,183		$43,435,213		$29,502,284
Right of Way Purchase	Percent of C	15%		$12,678,600		$4,649,850		$4,516,238		$2,029,122
Vehicle Procurement	Percent of D	5%		$6,556,875		$2,914,688		$2,407,088		$1,705,463
E. Capital Cost Subtotal				**$918,942,842**		**$390,195,669**		**$317,597,177**		**$207,303,588**
Project Reserve	Percent of E	10%		$91,894,284		$39,019,566.89		$31,759,717.75		$20,730,358.76
F. Total Capital Cost				**$1,010,837,127**		**$429,215,236**		**$349,356,895**		**$228,033,946**

Note: All costs are in Year 2001 Dollars

59th Avenue
LRT - Fleet Sizing and O&M Estimate

Item			Comments	
				peak headway
Travel/Track Miles of Line	18.99	18.99	For branches, miles = travel distance; not additive	15 on each line
Stations:				
* Surface	see total -------------	18		
* Aerial	see total -------------	1		
Operating Times:				
* 1-way run, minutes	*51.8*		Baseline to Bell, average NB/SB	
Round trip w/o recovery (min)	104		excluding turn-around time at ends of line	
* 2-way cycle, minutes	**115**		average cycle	
Vehicle Fleet:				
* Trains in service (peak)	8	8	combined - 15' peak headways (H)	
LRTs (Basic 2-car consist)	16	16		
* Cars in service (peak)	16	16		
* Fleet		19	In service + 20% spares	
Train & Car Hrs & Miles:				
* Train Hours:				
- Daily	104	104	7 hr @ 15' H, 12 hr @ 30' H	
* Car Hrs per day:				
- Base	104	104	Single cars, 19 hrs/day	
- Peak	104	104	*2nd car, 19 hrs/day*	
- Total	208	208		
* *Schedule* speed, mph	19.8		Includes dwell and recovery times	
* Car miles per day	4,118	4,118		
* Annualization:			300 equivalent weekdays/year	
- Car Hours	62,400	62,400		
- Car Miles	1,235,400	1,235,400		
O&M Cost Estimates:				
* Rev. Veh Hrs @ $67		$ 4.2	$ millions	
* Rev Veh Mi @ $2.09		$ 2.6	$ millions	
* Peak Veh @ $147000		$ 2.4	$ millions	
* Line Mi @ $82000		$ 1.6	$ millions	
* Pass Stations @ $26000		$ 0.49	$ millions	
* **Total Annual O&M**		**$11.29**	$ millions	

Bell Road

LRT - Fleet Sizing and O&M Estimate

Item			**Comments**
			peak headway **10** on each line
Travel/Track Miles of Line	28.55	28.55	
Stations:			
* Surface	see total -------------	27	
* Aerial	see total -------------	2	
Operating Times:			
* 1-way run, minutes	*77.9*		Scottsdale to Loop 303, average WB/EB
Round trip w/o recovery (min)	156		excluding turn-around time at ends of line
* 2-way cycle, minutes	**170**		average cycle
Vehicle Fleet:			
* Trains in service (peak)	17	17	combined - 10' peak headways (H)
LRTs (Basic 2-car consist)	34	34	
* Cars in service (peak)	34	34	
* Fleet		41	In service + 20% spares
Train & Car Hrs & Miles:			
* Train Hours:			
- Daily	221	221	7 hr @ 10' H, 12 hr @ 20' H
* Car Hrs per day:			
- Base	221	221	Single cars, 19 hrs/day
- Peak	221	221	*2nd car, 19 hrs/day*
- Total	442	442	
* *Schedule* speed, mph	20.2		Includes dwell and recovery times
* Car miles per day	8,928	8,928	
* Annualization:			300 equivalent weekdays/year
- Car Hours	132,600	132,600	
- Car Miles	2,678,400	2,678,400	
O&M Cost Estimates:			
* Rev. Veh Hrs @ $67		$ 8.9	$ millions
* Rev Veh Mi @ $2.09		$ 5.6	$ millions
* Peak Veh @ $147000		$ 5.0	$ millions
* Line Mi @ $82000		$ 2.3	$ millions
* Pass Stations @ $26000		$ 0.75	$ millions
*** Total Annual O&M**		**$22.55**	$ millions

Camelback Road
LRT - Fleet Sizing and O&M Estimate

Item			Comments	
				peak headway
Travel/Track Miles of Line	8.63	8.63	For branches, miles = travel distance; not additive	10
Stations:				on each line
* Surface	see total -------------	8		
* Aerial	see total -------------	1		
Operating Times:				
* 1-way run, minutes	*23.5*		Scottsdale to Loop 101, average WB/EB	
Round trip w/o recovery (min)	47		excluding turn-around time at ends of line	
* 2-way cycle, minutes	**57**		average cycle	
Vehicle Fleet:				
* Trains in service (peak)	6	6	combined - 10' peak headways (H)	
LRTs (Basic 2-car consist)	12	12		
* Cars in service (peak)	12	12		
* Fleet		14	In service + 20% spares	
Train & Car Hrs & Miles:				
* Train Hours:				
- Daily	78	78	7 hr @ 10' H, 12 hr @ 20' H	
* Car Hrs per day:				
- Base	78	78	Single cars, 19 hrs/day	
- Peak	78	78	*2nd car, 19 hrs/day*	
- Total	156	156		
* *Schedule* speed, mph	18.1		Includes dwell and recovery times	
* Car miles per day	2,824	2,824		
* Annualization:			300 equivalent weekdays/year	
- Car Hours	46,800	46,800		
- Car Miles	847,200	847,200		
O&M Cost Estimates:				
* Rev. Veh Hrs @ $67		$ 3.1	$ millions	
* Rev Veh Mi @ $2.09		$ 1.8	$ millions	
* Peak Veh @ $147000		$ 1.8	$ millions	
* Line Mi @ $82000		$ 0.7	$ millions	
* Pass Stations @ $26000		$ 0.23	$ millions	
*** Total Annual O&M**		**$7.63**	$ millions	

Central Avenue South
LRT - Fleet Sizing and O&M Estimate

Item			**Comments**	
				peak
Travel/Track Miles of Line	4.93	4.93	For branches, miles = travel	headway
Stations:			distance; not additive	**10**
* Surface	see total -------------	5		on each line
* Aerial	see total -------------	-		
Operating Times:				
* 1-way run, minutes	*13.4*		Jefferson Street to Baseline Road, average NB/SB	
Round trip w/o recovery (min)	27		excluding turn-around time at ends of line	
* 2-way cycle, minutes	**37**		average cycle	
Vehicle Fleet:				
* Trains in service (peak)	4	4	combined - 10' peak headways (H)	
LRTs (Basic 2-car consist)	8	8		
* Cars in service (peak)	8	8		
* Fleet		10	In service + 20% spares	
Train & Car Hrs & Miles:				
* Train Hours:				
- Daily	52	52	7 hr @ 10' H, 12 hr @ 20' H	
* Car Hrs per day:				
- Base	52	52	Single cars, 19 hrs/day	
- Peak	52	52	*2nd car, 19 hrs/day*	
- Crush	0	-	***3rd car, trains, 7hrs/day***	
- Total	104	104		
* *Schedule* speed, mph	16		Includes dwell and recovery times	
* Car miles per day	1,664	1,664		
* Annualization:			300 equivalent weekdays/year	
- Car Hours	31,200	31,200		
- Car Miles	499,200	499,200		
O&M Cost Estimates:				
* Rev. Veh Hrs @ $67		$ 2.1	$ millions	
* Rev Veh Mi @ $2.09		$ 1.0	$ millions	
* Peak Veh @ $147000		$ 1.2	$ millions	
* Line Mi @ $82000		$ 0.4	$ millions	
* Pass Stations @ $26000		$ 0.13	$ millions	
*** Total Annual O&M**		**$4.83**	$ millions	

Chandler Boulevard

LRT - Fleet Sizing and O&M Estimate

Item			**Comments**	
				peak headway
Travel/Track Miles of Line	16.45	16.45	For branches, miles = travel distance; not additive	15
Stations:				on each line
* Surface	see total -------------	14		
* Aerial	see total -------------	3		
Operating Times:				
* 1-way run, minutes	*44.9*		Ray Road to Power Road, average WB/EB	
Round trip w/o recovery (min)	90		excluding turn-around time at ends of line	
* 2-way cycle, minutes	**100**		average cycle	
Vehicle Fleet:				
* Trains in service (peak)	7	7	combined - 15' peak headways (H)	
LRTs (Basic 2-car consist)	14	14		
* Cars in service (peak)	14	14		
* Fleet		17	In service + 20% spares	
Train & Car Hrs & Miles:				
* Train Hours:				
- Daily	91	91	7 hr @ 15' H, 12 hr @ 30' H	
* Car Hrs per day:				
- Base	91	91	Single cars, 19 hrs/day	
- Peak	91	91	*2nd car, 19 hrs/day*	
- Total	182	182		
* *Schedule* speed, mph	19.7		Includes dwell and recovery times	
* Car miles per day	3,585	3,585		
* Annualization:			300 equivalent weekdays/year	
- Car Hours	54,600	54,600		
- Car Miles	1,075,500	1,075,500		
O&M Cost Estimates:				
* Rev. Veh Hrs @ $67		$ 3.7	$ millions	
* Rev Veh Mi @ $2.09		$ 2.2	$ millions	
* Peak Veh @ $147000		$ 2.1	$ millions	
* Line Mi @ $82000		$ 1.3	$ millions	
* Pass Stations @ $26000		$ 0.44	$ millions	
*** Total Annual O&M**		**$9.74**	$ millions	

Glendale Avenue
LRT - Fleet Sizing and O&M Estimate

Item			**Comments**	
				peak
Travel/Track Miles of Line	9.75	9.75	For branches, miles = travel	headway
Stations:			distance; not additive	10
* Surface	see total -------------	8		on each line
* Aerial	see total -------------	2		
Operating Times:				
* 1-way run, minutes	*26.6*		19th to Grand School, average WB/EB	
Round trip w/o recovery (min)	53		excluding turn-around time at ends of line	
* 2-way cycle, minutes	**63**		average cycle	
Vehicle Fleet:				
* Trains in service (peak)	7	7	combined - 10' peak headways (H)	
LRTs (Basic 2-car consist)	14	14		
* Cars in service (peak)	14	14		
* Fleet		17	In service + 20% spares	
Train & Car Hrs & Miles:				
* Train Hours:				
- Daily	91	91	7 hr @ 10' H, 12 hr @ 20' H	
* Car Hrs per day:				
- Base	91	91	Single cars, 19 hrs/day	
- Peak	91	91	*2nd car, 19 hrs/day*	
- Total	182	182		
* *Schedule* speed, mph	18.5		Includes dwell and recovery times	
* Car miles per day	3,367	3,367		
* Annualization:			300 equivalent weekdays/year	
- Car Hours	54,600	54,600		
- Car Miles	1,010,100	1,010,100		
O&M Cost Estimates:				
* Rev. Veh Hrs @ $67		$ 3.7	$ millions	
* Rev Veh Mi @ $2.09		$ 2.1	$ millions	
* Peak Veh @ $147000		$ 2.1	$ millions	
* Line Mi @ $82000		$ 0.8	$ millions	
* Pass Stations @ $26000		$ 0.26	$ millions	
*** Total Annual O&M**		**$8.96**	$ millions	

I-10 West

LRT - Fleet Sizing and O&M Estimate

Item			Comments	
				peak
Travel/Track Miles of Line	11.05	11.05	For branches, miles = travel	headway
Stations:			distance; not additive	10
* Surface	see total -------------	11		on each line
* Aerial	see total -------------	-		
Operating Times:				
* 1-way run, minutes	*30.1*		Central to Loop 101 W, average WB/EB	
Round trip w/o recovery (min)	60		excluding turn-around time at ends of line	
* 2-way cycle, minutes	**70**		average cycle	
Vehicle Fleet:				
* Trains in service (peak)	8	8	combined - 10' peak headways (H)	
LRTs (Basic 2-car consist)	16	16		
* Cars in service (peak)	16	16		
* Fleet		19	In service + 20% spares	
Train & Car Hrs & Miles:				
* Train Hours:				
- Daily	104	104	7 hr @ 10' H, 12 hr @ 20' H	
* Car Hrs per day:				
- Base	104	104	Single cars, 19 hrs/day	
- Peak	104	104	*2nd car, 19 hrs/day*	
- Total	208	208		
* *Schedule* speed, mph	18.9		Includes dwell and recovery times	
* Car miles per day	3,931	3,931		
* Annualization:			300 equivalent weekdays/year	
- Car Hours	62,400	62,400		
- Car Miles	1,179,300	1,179,300		
O&M Cost Estimates:				
* Rev. Veh Hrs @ $67		$ 4.2	$ millions	
* Rev Veh Mi @ $2.09		$ 2.5	$ millions	
* Peak Veh @ $147000		$ 2.4	$ millions	
* Line Mi @ $82000		$ 0.9	$ millions	
* Pass Stations @ $26000		$ 0.29	$ millions	
*** Total Annual O&M**		**$10.29**	$ millions	

Main Street
LRT - Fleet Sizing and O&M Estimate

Item			Comments	
				peak headway
Travel/Track Miles of Line	9.64	9.64	For branches, miles = travel distance; not additive	10
Stations:				on each line
* Surface	see total -------------	10		
* Aerial	see total -------------	-		
Operating Times:				
* 1-way run, minutes	*26.3*		Alma School to Power, average WB/EB	
Round trip w/o recovery (min)	53		excluding turn-around time at ends of line	
* 2-way cycle, minutes	**63**		average cycle	
Vehicle Fleet:				
* Trains in service (peak)	7	7	combined - 10' peak headways (H)	
LRTs (Basic 2-car consist)	14	14		
* Cars in service (peak)	14	14		
* Fleet		17	In service + 20% spares	
Train & Car Hrs & Miles:				
* Train Hours:				
- Daily	91	91	7 hr @ 10' H, 12 hr @ 20' H	
* Car Hrs per day:				
- Base	91	91	Single cars, 19 hrs/day	
- Peak	91	91	*2nd car, 19 hrs/day*	
- Total	182	182		
* *Schedule* speed, mph	18.5		Includes dwell and recovery times	
* Car miles per day	3,367	3,367		
* Annualization:			300 equivalent weekdays/year	
- Car Hours	54,600	54,600		
- Car Miles	1,010,100	1,010,100		
O&M Cost Estimates:				
* Rev. Veh Hrs @ $67		$ 3.7	$ millions	
* Rev Veh Mi @ $2.09		$ 2.1	$ millions	
* Peak Veh @ $147000		$ 2.1	$ millions	
* Line Mi @ $82000		$ 0.8	$ millions	
* Pass Stas @ $26000		$ 0.26	$ millions	
*** Total Annual O&M**		**$8.96**	$ millions	

Metrocenter/I-17
LRT - Fleet Sizing and O&M Estimate

Item			Comments	
				peak
Travel/Track Miles of Line	8.75	8.75	For branches, miles = travel	headway
Stations:			distance; not additive	10
* Surface	see total -------------	7		on each line
* Aerial	see total -------------	1		
Operating Times:				
* 1-way run, minutes	*23.9*		19th/Bethany Home to Bell Road, average NB/SB	
Round trip w/o recovery (min)	48		excluding turn-around time at ends of line	
* 2-way cycle, minutes	**58**		average cycle	
Vehicle Fleet:				
* Trains in service (peak)	6	6	combined - 10' peak headways (H)	
LRTs (Basic 2-car consist)	12	12		
* Cars in service (peak)	12	12		
* Fleet		14	In service + 20% spares	
Train & Car Hrs & Miles:				
* Train Hours:				
- Daily	78	78	7 hr @ 10' H, 12 hr @ 20' H	
* Car Hrs per day:				
- Base	78	78	Single cars, 19 hrs/day	
- Peak	78	78	*2nd car, 19 hrs/day*	
- Total	156	156		
* *Schedule* speed, mph	18.2		Includes dwell and recovery times	
* Car miles per day	2,839	2,839		
* Annualization:			300 equivalent weekdays/year	
- Car Hours	46,800	46,800		
- Car Miles	851,700	851,700		
O&M Cost Estimates:				
* Rev. Veh Hrs @ $67		$ 3.1	$ millions	
* Rev Veh Mi @ $2.09		$ 1.8	$ millions	
* Peak Veh @ $147000		$ 1.8	$ millions	
* Line Mi @ $82000		$ 0.7	$ millions	
* Pass Stations @ $26000		$ 0.21	$ millions	
*** Total Annual O&M**		**$7.61**	$ millions	

Power Road
LRT - Fleet Sizing and O&M Estimate

Item			Comments
Travel/Track Miles of Line	13.04	13.04	For branches, miles = travel distance; not additive — peak headway **15** on each line
Stations:			
* Surface	see total -------------	13	
* Aerial	see total -------------	1	
Operating Times:			
* 1-way run, minutes	*35.6*		Williams Field to McDowell/Higley, average NB/SB
Round trip w/o recovery (min)	71		excluding turn-around time at ends of line
* 2-way cycle, minutes	**81**		average cycle
Vehicle Fleet:			
* Trains in service (peak)	6	6	combined - 15' peak headways (H)
LRTs (Basic 2-car consist)	12	12	
* Cars in service (peak)	12	12	
* Fleet		14	In service + 20% spares
Train & Car Hrs & Miles:			
* Train Hours:			
- Daily	78	78	7 hr @ 15' H, 12 hr @ 30' H
* Car Hrs per day:			
- Base	78	78	Single cars, 19 hrs/day
- Peak	78	78	*2nd car, 19 hrs/day*
- Total	156	156	
* *Schedule* speed, mph	19.3		Includes dwell and recovery times
* Car miles per day	3,011	3,011	
* Annualization:			300 equivalent weekdays/year
- Car Hours	46,800	46,800	
- Car Miles	903,300	903,300	
O&M Cost Estimates:			
* Rev. Veh Hrs @ $67		$ 3.1	$ millions
* Rev Veh Mi @ $2.09		$ 1.9	$ millions
* Peak Veh @ $147000		$ 1.8	$ millions
* Line Mi @ $82000		$ 1.1	$ millions
* Pass Stations @ $26000		$ 0.36	$ millions
*** Total Annual O&M**		**$8.26**	$ millions

Scottsdale Road/UP Tempe Branch
LRT - Fleet Sizing and O&M Estimate

Item			Comments
			peak headway **10** on each line
Travel/Track Miles of Line	25.50	25.50	For branches, miles = travel distance; not additive
Stations:			
* Surface	see total -------------	25	
* Aerial	see total -------------	-	
Operating Times:			
* 1-way run, minutes	*69.5*		Price/Queen Creek to Bell, average NB/SB
Round trip w/o recovery (min)	139		excluding turn-around time at ends of line
* 2-way cycle, minutes	**155**		average cycle
Vehicle Fleet:			
* Trains in service (peak)	16	16	combined - 10' peak headways (H)
LRTs (Basic 2-car consist)	32	32	
* Cars in service (peak)	32	32	
* Fleet		38	In service + 20% spares
Train & Car Hrs & Miles:			
* Train Hours:			
- Daily	208	208	7 hr @ 10' H, 12 hr @ 20' H
* Car Hrs per day:			
- Base	208	208	Single cars, 19 hrs/day
- Peak	208	208	*2nd car, 19 hrs/day*
- Crush	0	-	***3rd car, trains, 7hrs/day***
- Total	416	416	
* *Schedule* speed, mph	19.7		Includes dwell and recovery times
* Car miles per day	8,195	8,195	
* Annualization:			300 equivalent weekdays/year
- Car Hours	124,800	124,800	
- Car Miles	2,458,500	2,458,500	
O&M Cost Estimates:			
* Rev. Veh Hrs @ $67		$ 8.4	$ millions
* Rev Veh Mi @ $2.09		$ 5.1	$ millions
* Peak Veh @ $147000		$ 4.7	$ millions
* Line Mi @ $82000		$ 2.1	$ millions
* Pass Stations @ $26000		$ 0.65	$ millions
* **Total Annual O&M**		**$20.95**	$ millions

SR-51

LRT - Fleet Sizing and O&M Estimate

Item			**Comments**	
				peak headway
Travel/Track Miles of Line	17.34	17.34	For branches, miles = travel distance; not additive	10
Stations:				on each line
* Surface	see total -------------	13		
* Aerial	see total -------------	4		
Operating Times:				
* 1-way run, minutes	*47.3*		Glendale 19th to Mayo Clinic, average NB/SB	
Round trip w/o recovery (min)	95		excluding turn-around time at ends of line	
* 2-way cycle, minutes	**105**		average cycle	
Vehicle Fleet:				
* Trains in service (peak)	11	11	combined - 10' peak headways (H)	
LRTs (Basic 2-car consist)	22	22		
* Cars in service (peak)	22	22		
* Fleet		26	In service + 20% spares	
Train & Car Hrs & Miles:				
* Train Hours:				
- Daily	143	143	7 hr @ 10' H, 12 hr @ 20' H	
* Car Hrs per day:				
- Base	143	143	Single cars, 19 hrs/day	
- Peak	143	143	*2nd car, 19 hrs/day*	
- Total	286	286		
* *Schedule* speed, mph	19.8		Includes dwell and recovery times	
* Car miles per day	5,663	5,663		
* Annualization:			300 equivalent weekdays/year	
- Car Hours	85,800	85,800		
- Car Miles	1,698,900	1,698,900		
O&M Cost Estimates:				
* Rev. Veh Hrs @ $67		$ 5.7	$ millions	
* Rev Veh Mi @ $2.09		$ 3.6	$ millions	
* Peak Veh @ $147000		$ 3.2	$ millions	
* Line Mi @ $82000		$ 1.4	$ millions	
* Pass Stations @ $26000		$ 0.44	$ millions	
*** Total Annual O&M**		**$14.34**	$ millions	

Union Pacific Chandler Branch
LRT - Fleet Sizing and O&M Estimate

Item			Comments	
				peak
Travel/Track Miles of Line	12.60	12.60	For branches, miles = travel	headway
Stations:			distance; not additive	**10**
* Surface	see total -------------	13		on each line
* Aerial	see total -------------	-		
Operating Times:				
* 1-way run, minutes	*34.4*		Price to Baseline, average NB/SB	
Round trip w/o recovery (min)	69		excluding turn-around time at ends of line	
* 2-way cycle, minutes	**79**		average cycle	
Vehicle Fleet:				
* Trains in service (peak)	8	8	combined - 10' peak headways (H)	
LRTs (Basic 2-car consist)	16	16		
* Cars in service (peak)	16	16		
* Fleet		19	In service + 20% spares	
Train & Car Hrs & Miles:				
* Train Hours:				
- Daily	104	104	7 hr @ 10' H, 12 hr @ 20' H	
* Car Hrs per day:				
- Base	104	104	Single cars, 19 hrs/day	
- Peak	104	104	*2nd car, 19 hrs/day*	
- Total	208	208		
* *Schedule* speed, mph	19.2		Includes dwell and recovery times	
* Car miles per day	3,994	3,994		
* Annualization:			300 equivalent weekdays/year	
- Car Hours	62,400	62,400		
- Car Miles	1,198,200	1,198,200		
O&M Cost Estimates:				
* Rev. Veh Hrs @ $67		$ 4.2	$ millions	
* Rev Veh Mi @ $2.09		$ 2.5	$ millions	
* Peak Veh @ $147000		$ 2.4	$ millions	
* Line Mi @ $82000		$ 1.0	$ millions	
* Pass Stations @ $26000		$ 0.34	$ millions	
*** Total Annual O&M**		**$10.44**	$ millions	

APPENDIX C

Dedicated BRT Estimated Capital Costs

Item	Units	Avg. Unit Cost	Amount	Bell Road	Amount	Camelback Road	Amount	Chandler Boulevard
Alignment Breakdown								
Surface (Median)	linear ft			150,769		45,566		86,876
Intersections	each			100		42		68
Signal Intersections	each			69		26		45
In Freeway								
Freeway Crossings								
Elevated	Aerial Rt Ft							
New Concrete Sidewalk/Curb/Gutter	linear ft	$27.46	140,769	$3,865,517	41,366	$1,135,910	80,076	$2,198,887
Construct AC Pavement & Base (new Roadway)	linear ft	$66.61	150,769	$10,042,723	45,566	$3,035,151	86,876	$5,786,810
Median Curb	linear ft	$8.13	140,769	$1,144,452	45,624	$370,923	80,076	$651,018
Reconstruct Intersection	each	$50,000	100	$5,000,000	42	$2,100,000	68	$3,400,000
Remove Existing Pavement/Curb/Gutter	linear ft	$12.54	150,769	$1,890,643	45,566	$571,398	86,876	$1,089,425
Roadway Excavation	Cubic Yard	$18.35	452,307	$8,299,833	136,698	$2,508,408	260,628	$4,782,524
Construct Concrete & Base (new Bus lanes)	linear ft	$184	150,769	$27,741,496	45,566	$8,384,144	86,876	$15,985,184
Signing/Striping	Percent of Above	5%		$2,899,233		$905,297		$1,694,692
Subtotal-Civil/Roadway				**$60,883,898**		**$19,011,231**		**$35,588,540**
Utility Relocation	linear ft	$350	150,769	$52,769,150	45,566	$15,948,100	86,876	$30,406,600
Subtotal-Utilities				**$52,769,150**		**$15,948,100**		**$30,406,600**
Surface Stations	Each	$700,000	29	$20,300,000	9	$6,300,000	17	$11,900,000
Surface Parking	Space	$2,800	2,175	$6,090,000	675	$1,890,000	1,275	$3,570,000
Parking Structures	Space	$9,500	2,175	$20,662,500	675	$6,412,500	1,275	$12,112,500
Elevated Ped Xings	Each	$1,000,000		$0		$0		$0
Subtotal-Stations				**$47,052,500**		**$14,602,500**		**$27,582,500**
Ticket Vending Machines	Each Station	$370,000	29	$10,730,000	9	$3,330,000	17	$6,290,000
On-Board AVL Equipment	Each Vehicle	$22,000	46	$1,012,000	14	$308,000	19	$418,000
On-Board Signal Priority System	Each Vehicle	$9,000	46	$414,000	14	$126,000	19	$171,000
Traffic Signal Priority and Intersections	Each	$20,000	69	$1,380,000	26	$520,000	45	$900,000
Signals and Communication	Station	$77,000	29	$2,233,000	9	$693,000	17	$1,309,000
Lighting At Grade	mile	$375,000	29	$10,708,026	9	$3,236,222	16	$6,170,170
Subtotal-Sys El				**$26,477,026**		**$8,213,222**		**$15,258,170**
Maintenance/Storage	Each			$6,900,000		$2,100,000		$2,850,000
AVL Equipment	Lump			$800,000		$800,000		$800,000
Operations Control	Each			$250,000		$250,000		$250,000
Subtotal Facilities				**$7,950,000**		**$3,150,000**		**$3,900,000**
A. Construction Subtotal				**$195,132,573**		**$60,925,053**		**$112,735,811**
Environmental Mitigation	Percent of A	2%		$3,902,651		$1,218,501		$2,254,716
B. Construction Cost Subtotal				**$199,035,225**		**$62,143,554**		**$114,990,527**
System Envelope	square foot	$25	3,237,687	$80,942,175	951,418	$23,785,450	1,841,748	$46,043,700
New Parking Spaces	square foot	$25	1,010,592	$25,264,800	313,632	$7,840,800	592,416	$14,810,400
C. Right of Way Subtotal				**$106,206,975**		**$31,626,250**		**$60,854,100**
Revenue Vehicles (40' Diesel Bus)	Each	$275,000	0	$0		$0		$0
Revenue Vehicles (40' CNG Bus)	Each	$360,000	0	$0	0	$0	0	$0
Revenue Vehicles (60' Articulated Bus)	Each	$440,000	46	$20,240,000	14	$6,160,000	19	$8,360,000
Spare Parts	Percent	10%		$2,024,000		$616,000		$836,000
D. Vehicles Subtotal				**$22,264,000**		**$6,776,000**		**$9,196,000**
Cost Contingencies (Uncertainties, Changes)								
Design&Construction	Percent of B	25%		$49,758,806		$15,535,889		$28,747,632
Right of Way	Percent of C	30%		$31,862,093		$9,487,875		$18,256,230
Vehicle Cost	Percent of D	10%		$2,226,400		$677,600		$919,600
Program Implementation (Agency Costs and Fees)								
Design&Construction	Percent of B	31%		$61,700,920		$19,264,502		$35,647,063
Right of Way Purchase	Percent of C	15%		$15,931,046		$4,743,938		$9,128,115
Vehicle Procurement	Percent of D	5%		$1,113,200		$338,800		$459,800
E. Capital Cost Subtotal				**$490,098,664**		**$150,594,407**		**$278,199,067**
Project Reserve	Percent of E	10%		$49,009,866		$15,059,441		$27,819,907
F. Total Capital Cost				**$539,108,531**		**$165,653,848**		**$306,018,974**

Note: All costs are in Year 2001 Dollars

Dedicated BRT Estimated Capital Costs

Item	Units	Avg. Unit Cost	Amount	Scottsdale Road	Amount	Power Road	Amount	SR-51
Alignment Breakdown								
Surface (Median)	linear ft			134,640		68,864		61,195
Intersections	each			117		45		37
Signal Intersections	each			71		35		24
In Freeway								30,360
Freeway Crossings								
Elevated	Aerial Rt Ft							
New Concrete Sidewalk/Curb/Gutter	linear ft	$27.46	85,360	$2,343,986	64,364	$1,767,435	57,495	$1,578,813
Construct AC Pavement & Base (new Roadway)	linear ft	$66.61	96,360	$6,418,540	68,864	$4,587,031	61,195	$4,076,199
Median Curb	linear ft	$8.13	122,940	$999,502	64,364	$523,279	57,495	$467,434
Reconstruct Intersection	each	$50,000	117	$5,850,000	45	$2,250,000	37	$1,850,000
Remove Existing Pavement/Curb/Gutter	linear ft	$12.54	97,060	$1,217,132	68,864	$863,555	61,195	$767,385
Roadway Excavation	Cubic Yard	$18.35	291,180	$5,343,153	206,592	$3,790,963	183,585	$3,368,785
Construct Concrete & Base (new Bus lanes)	linear ft	$184	134,640	$24,773,760	68,864	$12,670,976	61,195	$11,259,880
Signing/Striping	Percent of Above	5%		$2,347,304		$1,322,662		$1,168,425
Subtotal-Civil/Roadway				**$49,293,376**		**$27,775,902**		**$24,536,921**
Utility Relocation	linear ft	$350	134,640	$47,124,000	68,864	$24,102,400	61,195	$21,418,250
Subtotal-Utilities				**$47,124,000**		**$24,102,400**		**$21,418,250**
Surface Stations	Each	$700,000	25	$17,500,000	13	$9,100,000	17	$11,900,000
Surface Parking	Space	$2,800	1,875	$5,250,000	975	$2,730,000	1,275	$3,570,000
Parking Structures	Space	$9,500	1,875	$17,812,500	975	$9,262,500	1,275	$12,112,500
Elevated Ped Xings	Each	$1,000,000		$0		$0		$0
Subtotal-Stations				**$40,562,500**		**$21,092,500**		**$27,582,500**
Ticket Vending Machines	Each Station	$370,000	25	$9,250,000	13	$4,810,000	17	$6,290,000
On-Board AVL Equipment	Each Vehicle	$22,000	41	$902,000	11	$242,000	28	$616,000
On-Board Signal Priority System	Each Vehicle	$9,000	41	$369,000	11	$99,000	28	$252,000
Traffic Signal Priority and Intersections	Each	$20,000	71	$1,420,000	35	$700,000	24	$480,000
Signals and Communication	Station	$77,000	25	$1,925,000	13	$1,001,000	17	$1,309,000
Lighting At Grade	mile	$375,000	26	$9,562,500	13	$4,890,909	12	$4,346,236
Subtotal-Sys El				**$23,428,500**		**$11,742,909**		**$13,293,236**
Maintenance/Storage	Each			$6,150,000		$1,650,000		$4,200,000
AVL Equipment	Lump			$800,000		$800,000		$800,000
Operations Control	Each			$250,000		$250,000		$250,000
Subtotal Facilities				**$7,200,000**		**$2,700,000**		**$5,250,000**
A. Construction Subtotal				**$167,608,376**		**$87,413,711**		**$92,080,907**
Environmental Mitigation	Percent of A	2%		$3,352,168		$1,748,274		$1,841,618
B. Construction Cost Subtotal				**$170,960,544**		**$89,161,985**		**$93,922,525**
System Envelope	square foot	$25	2,827,620	$70,690,500	1,480,372	$37,009,300	1,322,385	$33,059,625
New Parking Spaces	square foot	$25	871,200	$21,780,000	453,024	$11,325,600	592,416	$14,810,400
C. Right of Way Subtotal				**$92,470,500**		**$48,334,900**		**$47,870,025**
Revenue Vehicles (40' Diesel Bus)	Each	$275,000		$0		$0		$0
Revenue Vehicles (40' CNG Bus)	Each	$360,000	0	$0	0	$0	0	$0
Revenue Vehicles (60' Articulated Bus)	Each	$440,000	41	$18,040,000	11	$4,840,000	28	$12,320,000
Spare Parts	Percent	10%		$1,804,000		$484,000		$1,232,000
D. Vehicles Subtotal				**$19,844,000**		**$5,324,000**		**$13,552,000**
Cost Contingencies (Uncertainties, Changes)								
Design&Construction	Percent of B	25%		$42,740,136		$22,290,496		$23,480,631
Right of Way	Percent of C	30%		$27,741,150		$14,500,470		$14,361,008
Vehicle Cost	Percent of D	10%		$1,984,400		$532,400		$1,355,200
Program Implementation (Agency Costs and Fees)								
Design&Construction	Percent of B	31%		$52,997,769		$27,640,215		$29,115,983
Right of Way Purchase	Percent of C	15%		$13,870,575		$7,250,235		$7,180,504
Vehicle Procurement	Percent of D	5%		$992,200		$266,200		$677,600
E. Capital Cost Subtotal				**$423,601,274**		**$215,300,901**		**$231,515,475**
Project Reserve	Percent of E	10%		$42,360,127		$21,530,090		$23,151,547
F. Total Capital Cost				**$465,961,401**		**$236,830,991**		**$254,667,022**

Note: All costs are in Year 2001 Dollars

Dedicated BRT Estimated Capital Costs

Item	Units	Avg. Unit Cost	Amount	Union Pacific Chandler Branch	Amount	Main	Amount	59th Avenue
Alignment Breakdown								
Surface (Median)	linear ft			66,528		50,899		100,289
Intersections	each			31		43		106
Signal Intersections	each			30		25		54
In Freeway								
Freeway Crossings								
Elevated	Aerial Rt Ft							
New Concrete Sidewalk/Curb/Gutter	linear ft	$27.46	63,428	$1,741,733	46,599	$1,279,609	89,689	$2,462,860
Construct AC Pavement & Base (new Roadway)	linear ft	$66.61	18,240	$1,214,966	50,899	$3,390,382	100,289	$6,680,250
Median Curb	linear ft	$8.13	63,428	$515,670	46,599	$378,850	89,689	$729,172
Reconstruct Intersection	each	$50,000	7	$350,000	43	$2,150,000	106	$5,300,000
Remove Existing Pavement/Curb/Gutter	linear ft	$12.54	20,740	$260,080	50,899	$638,273	100,289	$1,257,624
Roadway Excavation	Cubic Yard	$18.35	62,220	$1,141,737	152,697	$2,801,990	300,867	$5,520,909
Construct Concrete & Base (new Bus lanes)	linear ft	$184	66,528	$12,241,152	50,899	$9,365,416	100,289	$18,453,176
Signing/Striping	Percent of Above	5%		$873,267		$1,000,226		$2,020,200
Subtotal-Civil/Roadway				**$18,338,604**		**$21,004,746**		**$42,424,191**
Utility Relocation	linear ft	$350	66,528	$23,284,800	50,899	$17,814,650	100,289	$35,101,150
Subtotal-Utilities				**$23,284,800**		**$17,814,650**		**$35,101,150**
Surface Stations	Each	$700,000	13	$9,100,000	10	$7,000,000	19	$13,300,000
Surface Parking	Space	$2,800	975	$2,730,000	750	$2,100,000	1,425	$3,990,000
Parking Structures	Space	$9,500	975	$9,262,500	750	$7,125,000	1,425	$13,537,500
Elevated Ped Xings	Each	$1,000,000		$0		$0		$0
Subtotal-Stations				**$21,092,500**		**$16,225,000**		**$30,827,500**
Ticket Vending Machines	Each Station	$370,000	13	$4,810,000	10	$3,700,000	19	$7,030,000
On-Board AVL Equipment	Each Vehicle	$22,000	20	$440,000	16	$352,000	30	$660,000
On-Board Signal Priority System	Each Vehicle	$9,000	20	$180,000	16	$144,000	30	$270,000
Traffic Signal Priority and Intersections	Each	$20,000	30	$600,000	25	$500,000	54	$1,080,000
Signals and Communication	Station	$77,000	13	$1,001,000	10	$770,000	19	$1,463,000
Lighting At Grade	mile	$375,000	13	$4,725,000	10	$3,614,986	19	$7,122,798
Subtotal-Sys El				**$11,756,000**		**$9,080,986**		**$17,625,798**
Maintenance/Storage	Each			$3,000,000		$2,400,000		$4,500,000
AVL Equipment	Lump			$800,000		$800,000		$1,600,000
Operations Control	Each			$250,000		$250,000		$500,000
Subtotal Facilities				**$4,050,000**		**$3,450,000**		**$6,600,000**
A. Construction Subtotal				**$78,521,904**		**$67,575,382**		**$132,578,639**
Environmental Mitigation	Percent of A	2%		$1,570,438		$1,351,508		$2,651,573
B. Construction Cost Subtotal				**$80,092,342**		**$68,926,890**		**$135,230,212**
System Envelope	square foot	$25	1,458,844	$36,471,100	1,071,777	$26,794,425	2,062,847	$51,571,175
New Parking Spaces	square foot	$25	453,024	$11,325,600	348,480	$8,712,000	662,112	$16,552,800
C. Right of Way Subtotal				**$47,796,700**		**$35,506,425**		**$68,123,975**
Revenue Vehicles (40' Diesel Bus)	Each	$275,000		$0		$0		$0
Revenue Vehicles (40' CNG Bus)	Each	$360,000	0	$0	0	$0	0	$0
Revenue Vehicles (60' Articulated Bus)	Each	$440,000	20	$8,800,000	16	$7,040,000	30	$13,200,000
Spare Parts	Percent	10%		$880,000		$704,000		$1,320,000
D. Vehicles Subtotal				**$9,680,000**		**$7,744,000**		**$14,520,000**
Cost Contingencies (Uncertainties, Changes)								
Design&Construction	Percent of B	25%		$20,023,086		$17,231,722		$33,807,553
Right of Way	Percent of C	30%		$14,339,010		$10,651,928		$20,437,193
Vehicle Cost	Percent of D	10%		$968,000		$774,400		$1,452,000
Program Implementation (Agency Costs and Fees)								
Design&Construction	Percent of B	31%		$24,828,626		$21,367,336		$41,921,366
Right of Way Purchase	Percent of C	15%		$7,169,505		$5,325,964		$10,218,596
Vehicle Procurement	Percent of D	5%		$484,000		$387,200		$726,000
E. Capital Cost Subtotal				**$205,381,269**		**$167,915,864**		**$326,436,894**
Project Reserve	Percent of E	10%		$20,538,127		$16,791,586		$32,643,689
F. Total Capital Cost				**$225,919,396**		**$184,707,451**		**$359,080,584**

Note: All costs are in Year 2001 Dollars

Dedicated BRT Estimated Capital Costs

Item	Units	Avg. Unit Cost	Amount	Grand Avenue
Alignment Breakdown				
Surface (Median)	linear ft			136,224
Intersections	each			71
Signal Intersections	each			38
In Freeway				
Freeway Crossings				
Elevated	Aerial Rt Ft			
New Concrete Sidewalk/Curb/Gutter	linear ft	$27.46	57,000	$1,565,220
Construct AC Pavement & Base (new Roadway)	linear ft	$66.61	0	$0
Median Curb	linear ft	$8.13	0	$0
Reconstruct Intersection	each	$50,000	38	$1,900,000
Remove Existing Pavement/Curb/Gutter	linear ft	$12.54	57,000	$714,780
Roadway Excavation	Cubic Yard	$18.35	171,000	$3,137,850
Construct Concrete & Base (new Bus lanes)	linear ft	$184	57,000	$10,488,000
Signing/Striping	Percent of Above	5%		$890,293
Subtotal-Civil/Roadway				**$18,696,143**
Utility Relocation	linear ft	$350	57,000	$19,950,000
Subtotal-Utilities				**$19,950,000**
Surface Stations	Each	$700,000	13	$9,100,000
Surface Parking	Space	$2,800	975	$2,730,000
Parking Structures	Space	$9,500	975	$9,262,500
Elevated Ped Xings	Each	$1,000,000		$0
Subtotal-Stations				**$21,092,500**
Ticket Vending Machines	Each Station	$370,000	13	$4,810,000
On-Board AVL Equipment	Each Vehicle	$22,000	53	$1,166,000
On-Board Signal Priority System	Each Vehicle	$9,000	53	$477,000
Traffic Signal Priority and Intersections	Each	$20,000	38	$760,000
Signals and Communication	Station	$77,000	13	$1,001,000
Lighting At Grade	mile	$375,000	26	$9,817,500
Subtotal-Sys El				**$18,031,500**
Maintenance/Storage	Each			$7,950,000
AVL Equipment	Lump			$1,200,000
Operations Control	Each			$500,000
Subtotal Facilities				**$9,650,000**
A. Construction Subtotal				**$87,420,143**
Environmental Mitigation	Percent of A	2%		$1,748,403
B. Construction Cost Subtotal				**$89,168,545**
System Envelope	square foot	$25	874,000	$21,850,000
New Parking Spaces	square foot	$25	453,024	$11,325,600
C. Right of Way Subtotal				**$33,175,600**
Revenue Vehicles (40' Diesel Bus)	Each	$275,000		$0
Revenue Vehicles (40' CNG Bus)	Each	$360,000	53	$19,080,000
Revenue Vehicles (60' Articulated Bus)	Each	$440,000	0	$0
Spare Parts	Percent	10%		$1,908,000
D. Vehicles Subtotal				**$20,988,000**
Cost Contingencies (Uncertainties, Changes)				
Design&Construction	Percent of B	25%		$22,292,136
Right of Way	Percent of C	30%		$9,952,680
Vehicle Cost	Percent of D	10%		$2,098,800
Program Implementation (Agency Costs and Fees)				
Design&Construction	Percent of B	31%		$27,642,249
Right of Way Purchase	Percent of C	15%		$4,976,340
Vehicle Procurement	Percent of D	5%		$1,049,400
E. Capital Cost Subtotal				**$211,343,751**
Project Reserve	Percent of E	10%		$21,134,375
F. Total Capital Cost				**$232,478,126**

Note: All costs are in Year 2001 Dollars

59th Avenue
BRT - Fleet Sizing and O&M Estimate

Item			Comments
			peak headway **5** on each line
Travel/Miles of Line	18.99	18.99	
Stations:			
* Surface	see total -------------	27	
* Aerial	see total -------------	-	
Operating Times:			
* 1-way run, minutes	*51.8*		51st Ave/Baseline to Bell, average NB/SB
Round trip w/o recovery (min)	104		excluding turn-around time at ends of line
* 2-way cycle, minutes	**124**		average cycle
Vehicle Fleet:			
* Buses in service (peak)	25	25	combined - 5' peak headways (H)
* Buses in service (off-peak)			
* Fleet		30	In service + 20% spares
Bus Hrs & Miles:			
* Bus Hours:			
- Daily	325	325	7 hr @ 5' H, 12 hr @ 10' H
* Bus Hrs per day:			
- Base	325	325	Single vehicle, 19 hrs/day
- Peak	0	-	
- Crush	-	-	
- Total	325	325	
* *Schedule* speed, mph	18.3		Includes dwell and recovery times
* Bus miles per day	5,948	5,948	
* Annualization:			300 equivalent weekdays/year
- Bus Hours	97,500	97,500	
- Bus Miles	1,784,400	1,784,400	
O&M Cost Estimates (current 2001 Valley Metro):			
* Rev. Veh Hrs @ $96.52		9.41	$ millions
* Rev Veh Mi @ $6.26		11.17	$ millions
*** Total Annual O&M**		**10.29**	$ millions

All costs in Year 2001 Dollars

Bell Road

BRT - Fleet Sizing and O&M Estimate

Item			**Comments**	
				peak
Travel/Miles of Line	28.55	28.55		headway
Stations:				5
* Surface	see total -------------	29		on each line
* Aerial	see total -------------			
Operating Times:				
* 1-way run, minutes	*77.9*		Scottsdale to Loop 303, average WB/EB	
Round trip w/o recovery (min)	156		excluding turn-around time at ends of line	
* 2-way cycle, minutes	**187**		average cycle	
Vehicle Fleet:				
* Buses in service (peak)	38	38	combined - 5' peak headways (H)	
* Fleet		46	In service + 20% spares	
Bus Hrs & Miles:				
* Bus Hours:				
- Daily	494	494	7 hr @ 5' H, 12 hr @ 10' H	
* Bus Hrs per day:				
- Base	494	494	Single vehicle, 19 hrs/day	
- Total	494	494		
* *Schedule* speed, mph	18.3		Includes dwell and recovery times	
* Bus miles per day	9,040	9,040		
* Annualization:			300 equivalent weekdays/year	
- Bus Hours	148,200	148,200		
- Bus Miles	2,712,000	2,712,000		
O&M Cost Estimates (current 2001 Valley Metro):				
* Rev. Veh Hrs @ $96.52		14.30	$ millions	
* Rev Veh Mi @ $6.26		16.98	$ millions	
*** Total Annual O&M**		**15.64**	$ millions	

All costs in Year 2001 Dollars

Camelback Road
BRT - Fleet Sizing and O&M Estimate

Item			Comments
			peak headway **5** on each line
Travel/Miles of Line	8.63	8.63	
Stations:			
* Surface	see total -------------	9	
* Aerial	see total -------------	-	
Operating Times:			
* 1-way run, minutes	*23.5*		Scottsdale to Loop 101, average WB/EB
Round trip w/o recovery (min)	47		excluding turn-around time at ends of line
* 2-way cycle, minutes	**57**		average cycle
Vehicle Fleet:			
* Buses in service (peak)	12	12	combined - 5' peak headways (H)
* Fleet		14	In service + 20% spares
Bus Hrs & Miles:			
* Bus Hours:			
- Daily	156	156	7 hr @ 5' H, 12 hr @ 10' H
* Bus Hrs per day:			
- Base	156	156	Single vehicle, 19 hrs/day
- Peak	0	-	
- Crush	-	-	
* *Schedule* speed, mph	18.1		Includes dwell and recovery times
* Bus miles per day	2,824	2,824	
* Annualization:			300 equivalent weekdays/year
- Bus Hours	46,800	46,800	
- Bus Miles	847,200	847,200	
O&M Cost Estimates (current 2001 Valley Metro):			
* Rev. Veh Hrs @ $96.52		4.52	$ millions
* Rev Veh Mi @ $6.26		5.30	$ millions
*** Total Annual O&M**		**4.91**	$ millions

All costs in Year 2001 Dollars

Chandler Boulevard
BRT - Fleet Sizing and O&M Estimate

Item			**Comments**
			peak headway **7** on each line
Travel/Miles of Line	16.45	16.45	
Stations:			
* Surface	see total -------------	17	
* Aerial	see total -------------	-	
Operating Times:			
* 1-way run, minutes	*44.9*		Ray to Power, average WB/EB
Round trip w/o recovery (min)	90		excluding turn-around time at ends of line
* 2-way cycle, minutes	**108**		average cycle
Vehicle Fleet:			
* Buses in service (peak)	16	16	combined - 7' peak headways (H)
* Buses in service (off-peak)			
* Fleet		19	In service + 20% spares
Bus Hrs & Miles:			
* Bus Hours:			
- Daily	208	208	7 hr @ 7' H, 12 hr @ 14' H
* Bus Hrs per day:			
- Base	208	208	Single vehicle, 19 hrs/day
- Peak	0	-	
- Crush	-	-	
- Total	208	208	
* *Schedule* speed, mph	18.3		Includes dwell and recovery times
* Bus miles per day	3,806	3,806	
* Annualization:			300 equivalent weekdays/year
- Bus Hours	62,400	62,400	
- Bus Miles	1,141,800	1,141,800	
O&M Cost Estimates (current 2001 Valley Metro):			
* Rev. Veh Hrs @ $96.52		6.02	$ millions
* Rev Veh Mi @ $6.26		7.15	$ millions
*** Total Annual O&M**		**6.59**	$ millions

All costs in Year 2001 Dollars

Grand Avenue BRT

BRT - Fleet Sizing and O&M Estimate

Item			**Comments**	
				peak
Travel/Miles of Line	25.80	25.80		headway
Stations:				5
* Surface	see total -------------	13		on each line
* Aerial	see total -------------	-		
Operating Times:				
* 1-way run, minutes	*91.1*		Loop 303 to Central, average NB/SB	
Round trip w/o recovery (min)	182		excluding turn-around time at ends of line	
* 2-way cycle, minutes	**219**		average cycle	
Vehicle Fleet:				
* Buses in service (peak)	44	44	combined - 5' peak headways (H)	
* Buses in service (off-peak)				
* Fleet		53	In service + 20% spares	
Bus Hrs & Miles:				
* Bus Hours:				
- Daily	572	572	7 hr @ 5' H, 12 hr @ 10' H	
* Bus Hrs per day:				
- Base	572	572	Single vehicle, 19 hrs/day	
- Peak	0	-		
- Crush	-	-		
- Total	572	572		
* *Schedule* speed, mph	14.2		Includes dwell and recovery times	
* Bus miles per day	8,122	8,122		
* Annualization:			300 equivalent weekdays/year	
- Bus Hours	171,600	171,600		
- Bus Miles	2,436,600	2,436,600		
O&M Cost Estimates (current 2001 Valley Metro):				
* Rev. Veh Hrs @ $96.52		16.56	$ millions	
* Rev Veh Mi @ $6.26		15.25	$ millions	
*** Total Annual O&M**		**15.91**	$ millions	

Main Street
BRT - Fleet Sizing and O&M Estimate

Item			Comments	
				peak headway
Travel/Miles of Line	9.64	9.64		5
Stations:				on each line
* Surface	see total -------------	10		
* Aerial	see total -------------	-		
Operating Times:				
* 1-way run, minutes	*26.3*		Alma School to Power, average WB/EB	
Round trip w/o recovery (min)	53		excluding turn-around time at ends of line	
* 2-way cycle, minutes	**63**		average cycle	
Vehicle Fleet:				
* Buses in service (peak)	13	13	combined - 5' peak headways (H)	
* Buses in service (off-peak)				
* Fleet		16	In service + 20% spares	
Bus Hrs & Miles:				
* Bus Hours:				
- Daily	169	169	7 hr @ 5' H, 12 hr @ 10' H	
* Bus Hrs per day:				
- Base	169	169	Single vehicle, 19 hrs/day	
- Peak	0	-		
- Crush	-	-		
- Total	169	169		
* *Schedule* speed, mph	18.3		Includes dwell and recovery times	
* Bus miles per day	3,093	3,093		
* Annualization:			300 equivalent weekdays/year	
- Bus Hours	50,700	50,700		
- Bus Miles	927,900	927,900		
O&M Cost Estimates (current 2001 Valley Metro):				
* Rev. Veh Hrs @ $96.52		4.89	$ millions	
* Rev Veh Mi @ $6.26		5.81	$ millions	
*** Total Annual O&M**		**5.35**	$ millions	

All costs in Year 2001 Dollars

Power Road

BRT - Fleet Sizing and O&M Estimate

Item			**Comments**
			peak headway **10** on each line
Travel/Miles of Line	13.04	13.04	
Stations:			
* Surface	see total -------------	13	
* Aerial	see total -------------	-	
Operating Times:			
* 1-way run, minutes	*35.6*		McDowell/Higley to Williams Field, average NB/SB
Round trip w/o recovery (min)	71		excluding turn-around time at ends of line
* 2-way cycle, minutes	**85**		average cycle
Vehicle Fleet:			
* Buses in service (peak)	9	9	combined - 10' peak headways (H)
* Buses in service (off-peak)			
* Fleet		11	In service + 20% spares
Bus Hrs & Miles:			
* Bus Hours:			
- Daily	117	117	7 hr @ 10' H, 12 hr @ 20' H
* Bus Hrs per day:			
- Base	117	117	Single vehicle, 19 hrs/day
- Peak	0	-	
- Crush	-	-	
- Total	117	117	
* *Schedule* speed, mph	18.3		Includes dwell and recovery times
* Bus miles per day	2,141	2,141	
* Annualization:			300 equivalent weekdays/year
- Bus Hours	35,100	35,100	
- Bus Miles	642,300	642,300	
O&M Cost Estimates (current 2001 Valley Metro):			
* Rev. Veh Hrs @ $96.52		3.39	$ millions
* Rev Veh Mi @ $6.26		4.02	$ millions
*** Total Annual O&M**		**3.71**	$ millions

All costs in Year 2001 Dollars

Scottsdale Road/UP Tempe Branch
BRT - Fleet Sizing and O&M Estimate

Item			**Comments**	
				peak
Travel/Miles of Line	25.50	25.50		headway
Stations:				5
* Surface	see total -------------	25		on each line
* Aerial	see total -------------	-		
Operating Times:				
* 1-way run, minutes	*69.5*		Price/Queen Creek to Bell, average NB/SB	
Round trip w/o recovery (min)	139		excluding turn-around time at ends of line	
* 2-way cycle, minutes	**167**		average cycle	
Vehicle Fleet:				
* Buses in service (peak)	34	34	combined - 5' peak headways (H)	
* Buses in service (off-peak)				
* Fleet		41	In service + 20% spares	
Bus Hrs & Miles:				
* Bus Hours:				
- Daily	442	442	7 hr @ 5' H, 12 hr @ 10' H	
* Bus Hrs per day:				
- Base	442	442	Single vehicle, 19 hrs/day	
- Peak	0	-		
- Crush	-	-		
- Total	442	442		
* *Schedule* speed, mph	18.3		Includes dwell and recovery times	
* Bus miles per day	8,089	8,089		
* Annualization:			300 equivalent weekdays/year	
- Bus Hours	132,600	132,600		
- Bus Miles	2,426,700	2,426,700		
O&M Cost Estimates (current 2001 Valley Metro):				
* Rev. Veh Hrs @ $96.52		12.80	$ millions	
* Rev Veh Mi @ $6.26		15.19	$ millions	
*** Total Annual O&M**		**14.00**	$ millions	

All costs in Year 2001 Dollars

SR-51

BRT - Fleet Sizing and O&M Estimate

Item			**Comments**
			peak headway **5** on each line
Travel/Miles of Line	17.34	17.34	
Stations:			
* Surface	see total -------------	17	
* Aerial	see total -------------	-	
Operating Times:			
* 1-way run, minutes	*47.3*		Camelback/Central to Bell/Scottsdale, average WB/EB
Round trip w/o recovery (min)	95		excluding turn-around time at ends of line
* 2-way cycle, minutes	**113**		average cycle
Vehicle Fleet:			
* Buses in service (peak)	23	23	combined - 5' peak headways (H)
* Buses in service (off-peak)			
* Fleet		28	In service + 20% spares
Bus Hrs & Miles:			
* Bus Hours:			
- Daily	299	299	7 hr @ 5' H, 12 hr @ 10' H
* Bus Hrs per day:			
- Base	299	299	Single vehicle, 19 hrs/day
- Peak	0	-	
- Crush	-	-	
- Total	299	299	
* *Schedule* speed, mph	18.3		Includes dwell and recovery times
* Bus miles per day	5,472	5,472	
* Annualization:			300 equivalent weekdays/year
- Bus Hours	89,700	89,700	
- Bus Miles	1,641,600	1,641,600	
O&M Cost Estimates (current 2001 Valley Metro):			
* Rev. Veh Hrs @ $96.52		8.66	$ millions
* Rev Veh Mi @ $6.26		10.28	$ millions
*** Total Annual O&M**		**9.47**	$ millions

All costs in Year 2001 Dollars

Union Pacific Chandler Branch
BRT - Fleet Sizing and O&M Estimate

Item			Comments
			peak headway 5 on each line
Travel/Miles of Line	12.60	12.60	
Stations:			
* Surface	see total -------------	13	
* Aerial	see total -------------	-	
Operating Times:			
* 1-way run, minutes	*34.4*		Baseline to Price/Queen Creek, average NB/SB
Round trip w/o recovery (min)	69		excluding turn-around time at ends of line
* 2-way cycle, minutes	**82**		average cycle
Vehicle Fleet:			
* Buses in service (peak)	17	17	combined - 5' peak headways (H)
* Buses in service (off-peak)			
* Fleet		20	In service + 20% spares
Bus Hrs & Miles:			
* Bus Hours:			
- Daily	221	221	7 hr @ 5' H, 12 hr @ 10' H
* Bus Hrs per day:			
- Base	221	221	Single vehicle, 19 hrs/day
- Peak	0	-	
- Crush	-	-	
- Total	221	221	
* *Schedule* speed, mph	18.3		Includes dwell and recovery times
* Bus miles per day	4,044	4,044	
* Annualization:			300 equivalent weekdays/year
- Bus Hours	66,300	66,300	
- Bus Miles	1,213,200	1,213,200	
O&M Cost Estimates (current 2001 Valley Metro):			
* Rev. Veh Hrs @ $96.52		6.40	$ millions
* Rev Veh Mi @ $6.26		7.59	$ millions
*** Total Annual O&M**		**7.00**	$ millions

All costs in Year 2001 Dollars